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Cover: Silver Tree

[*Courtesy W. H. R. Shaw, Department of Chemistry, University of Texas, see page 367*]

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Science and Technology

(From the month's news releases; publication here does not constitute endorsement.)

Electric Repair Kit

The electric repair kit includes everything needed for simple electric work. A pliers-like tool cuts and strips wire, crimps solderless terminals and connectors, and shears bolts and screws. Splices, terminals, connectors, and wire insulation are included in the kit. (Aircraft-Marine Products Inc., Consumers Products Div., Dept. SM, 2100 Paxton St., Harrisburg, Pa.)

Colorimeter

The Davis-Bruning colorimeter reduces what the eye sees to a numerical formula that gives a permanent "color memory." Light from the sample is projected on the left half of a white screen, and light from a series of eight standard color plaques is mixed in variable proportions and projected on the right half of the screen. Direct-reading drums show the percentage of each reference used. The instrument's optical system is designed so that only diffuse light reaches the screen. One tungsten lamp lights all six comparison stations, and baffles prevent the blended reference colors from spilling over onto the sample color. (Fisher Scientific Co., Dept. SM, 711 Forbes St., Pittsburgh 19, Pa.)

Power Plane

A new heavy-duty electric plane operates a 2 13/32-in. spiral cutter at 25,000 rev/min and removes up to 3/32 in. of wood. The plane weighs 9¼ lb and is 16 in. long, 8¾ in. wide, and 7¾ in. high. It is equipped with a trigger switch, adjustable guide fence, cable deflector, chip deflector, depth adjustment, and −15° to +45° bevel adjustment. The motor brushes and commutator are accessible. (Porter-Cable Machine Co., Dept. SM, 36 Exchange Pl., Syracuse 8, N.Y.)

Underground Lawn Sprinkler

Bakelite polyethylene flexible pipe is furnished along with the necessary sprinkler heads and T-fittings in a kit for building an underground sprinkler system. The pipe does not rust or rot, and it will expand without breaking during freezing weather. The system can be assembled with saw and screwdriver and then placed in a shallow trench under the sod. (PlastiPipe, Inc., Dept. SM, 5544 W. 104 St., Los Angeles 45, Calif.)

Calculating Exposure Meter

A German-made calculating exposure meter reads the light and automatically indicates nine possible combinations of shutter and lens settings. The built-in calculator frees the user from operating sliding scales or performing mental arithmetic. The meter also contains a "red flag" signal that tells the photographer when the light is too low. (Willoughbys, Dept. SM, 110 W. 32 St., New York 1.)

Microprint Reader

This reader features a typewriter-like platen for selecting the portion of the card desired and a green viewing screen designed to eliminate glare spots, which permits several persons to view the screen simultaneously. The screen is inclined in order that the user may assume a natural reading posture. The reader accommodates microprint cards up to 8 by 14 in., magnifies the image 22 times, and projects it onto an 8¾- by 10½-in. screen. (Eastman Kodak Company, Dept. SM, Rochester 4, N.Y.)

Soldering Flux

Poly-Flux is a liquid flux formulated to make solder flow and hold on iron and steel as easily as it flows and holds on copper, bronze, zinc, and other metals. It contains no harsh chemicals but removes surface oxides. Iron and steel joints may be soldered by ordinary methods. (Industrial Craftsmen, Inc., Dept. SM, 145 High St., Boston 10, Mass.)

Rust Remover

A new nonelectrolytic alkaline rust remover, Alka-Deox 114, is a free-flowing powder that is used in a concentration of from 1 to 3 lb/gal of water. Rapid removal of rust, paints, organic coatings, and other surface contaminants is accomplished when a solution of the salts is heated from 180°F to the boiling point. (Enthone, Inc., Dept. SM, 442 Elm St., New Haven, Conn.)

Corner Clamp

Wood and other materials up to 4½ in. in width can be held in position for fastening with a new corner clamp (Fig. 1). Because the two clamping screws can be adjusted independently, materials of different widths can be clamped at right angles. The clamp's base and sidewalls are provided with openings through which fastening operations can be performed. (Gunver Mfg. Co., Dept. SM, Hartford Rd., Manchester, Conn.)

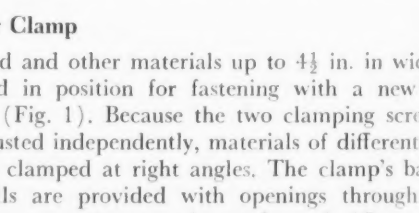


Fig. 1.

Cent-O-Gram Balance

The Cent-O-Gram triple-beam balance (Fig. 2) bridges the gap between the analytic balance and the conventional trip balance. It has a sensitivity of 0.01 g and a capacity of 311 g. Graduated beams, pan bows, weighing pan, and other exposed parts are constructed of stainless steel. (Ohaus Scale Corp., Dept. SM, 1060 Commerce Ave., Union, N.J.)

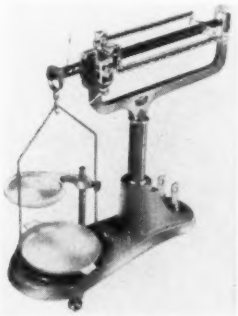


Fig. 2.

Asbestos-and-Aluminum Insulation

Insul-Attic insulation is made of asbestos laminated with aluminum foil. About the thickness of cardboard, it will not itself hold quantities of heat during the day and then release this heat at night. The aluminum foil provides a moisture barrier, and the material is fireproof and rodentproof. Packed in lightweight rolls, this insulation can be tacked or stapled to wall and overhead studding. (Abbeon Supply Co., Dept. SM, 179–21 Jamaica Ave., Jamaica 32, N.Y.)

Proportional Counter Converter

A new converter with a built-in low-voltage power supply and needle valve for gas-flow control converts any scaler with a high-voltage range of 600 to 2000 v to a proportional counter that will count both alpha and beta particles and detect either in the presence of the other. The unit is designed to count such samples as precipitates, evaporated salts, pellets, and ashed and filtered samples. Its input sensitivity is adjustable from 0.5 to 2.5 mv. Decontamination, including disassembly and reassembly, requires less than 10 min. (Nuclear Measurements Corp., Dept. SM, 2460 N. Arlington Ave., Indianapolis 18, Ind.)

Galvanometer Amplifier

A new galvanometer amplifier extends the usefulness of piezoelectric and other pickups by providing sufficient output current to drive high-frequency galvanometers and magnetic recording heads. Input impedance is 1000 Mohm; sensitivity is flat within ± 1 percent from 5 to 5000 cy/sec with output transformer, and from 1 to 20,000 cy/sec without transformer. Etched wiring, Tantalytic capacitors, and ruggedized tubes assure performance under extreme conditions. (Endevco Corp., Sales Dept., Dept. SM, 689 S. Fair Oaks Ave., Pasadena 2, Calif.)

Thermocouple Welder

Kup-L-Weld is a new instrument that enables laboratory technicians to make thermocouples by adding flux to the metal, touching the couple to the electrode, and pushing a button. Many different metals in wire sizes from 14 to 30 can be joined. All components are encased in a single housing, and an adjustable filter protects the operator from flash. The unit operates on conventional current. (Burrell Corp., Dept. SM, 2223 5th Ave., Pittsburgh 19, Pa.)

Hygrometer

A new hygrometer determines relative humidity by measuring the electric resistance of a carbon film. This instrument consists of a polystyrene strip coated with carbon powder in a water-sensitive binding compound. When the humidity is low, the resistance of the carbon is also low because the carbon particles are close together. When the humidity is high, the binder absorbs water and forces the carbon particles apart, whereupon the resistance of the carbon strip increases. (Arthur D. Little, Inc., Dept. SM, 30 Memorial Dr., Cambridge, Mass.)

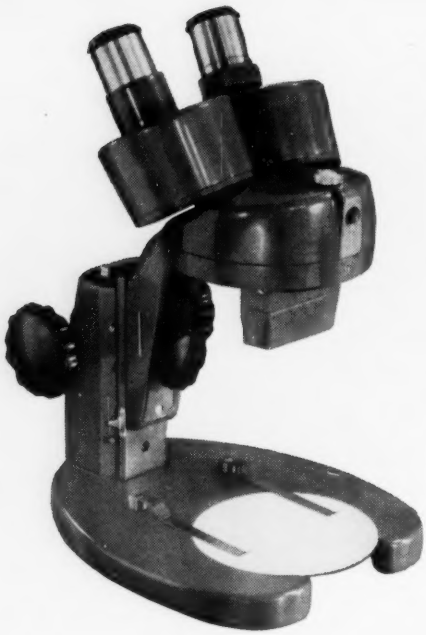
Tele-Thermometer

A Carboloy thermistor at the tip of a 10-ft flexible probe lead on a new Tele-Thermometer allows continuous measurement of a patient's internal temperature at any point during surgery. The length of the lead permits the indicating dial to be placed at any convenient location. The instrument is powered by one standard flashlight cell, has a temperature range from 68 to 108°F, and is accurate to ± 0.4°F. (Yellow Springs Instrument Co., Inc., Dept. SM, Yellow Springs, O.)

Relay-Type Timer

Model AT-1 Dual Timer (Fig. 3) can be used in conjunction with scaling units calling for a relay-type timer. The new timer has a range from 2 sec to 60 min with 1-sec increments and can be used for either predetermined or elapsed time operation. The required power, 110 v, 60 cy/sec, can be obtained from the scaling unit used. (The Atomic Center for Instruments and Equipment, Inc., Dept. SM, 489 Fifth Ave., New York 17.)

Fig. 3.



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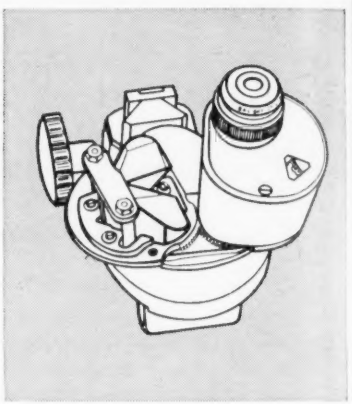

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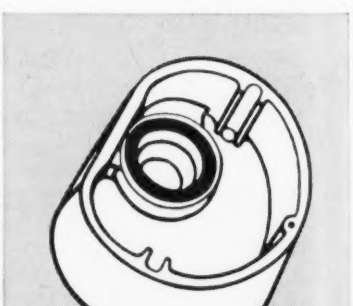

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STEREOMICROSCOPES

THE SCIENTIFIC MONTHLY

DECEMBER 1954

Storm of Balaklava and the Daily Weather Forecast

H. LANDSBERG

Dr. Landsberg was trained in geophysics and meteorology at the University of Frankfurt. He taught these subjects at Pennsylvania State University and the University of Chicago. During World War II he was consultant to the U.S. Air Force. He has served as research administrator in various agencies of the Defense Department and is now chief of Climatological Services of the U.S. Weather Bureau.

THE history of science and general history are closely linked. In this atomic age we have ample evidence for this linkage. It is, however, nothing new. The case history I want to relate here dates back to the Victorian age.

Just a century ago Balaklava was in the focus of world attention. This little harbor town lies on the southwest shore of the Crimean Peninsula a few miles south of the big port, Sevastopol. In 1854 Sevastopol was the main Russian naval base in the Black Sea, and the great powers of Europe were battling in this area. The Czar's army had invaded the domain of Turkey under the pretext of protecting Eastern Christendom. Actually it was an attempt to extend Russian hegemony over the Balkans and the Danube basin. It is interesting to note that where the Czar failed, his Communist successors accomplished most of this conquest nine decades later at the conference table of Yalta, just an hour's drive east of Balaklava. In 1854, however, the combined forces of western Europe stopped the Russian drive. Ostensibly the Western powers desired to keep intact the comfortable balance of power that had maintained European peace since the end of the adventures of Napoleon I, whose nephew, Prince Charles Louis Napoleon Bonaparte, had ascended the French throne in 1852 by *coup d'état* as Napoleon III. Louis Napoleon had need to bolster his throne by some glorious victories. England's government, spurred on by the London *Times,* felt that the rising Russian naval power was not in the interest of a Britannia that ruled the waves.

To put the Czar in his place, a powerful British-French fleet sailed to the Black Sea in October 1854. An army landed on the shores of the Crimea and, after a few skirmishes, began a blockade and siege of Sevastopol. Balaklava became the supply port for the allies. It was soon menaced by a large Russian land army that had rallied to the support of the garrison and fleet which were bottled up in Sevastopol.

In the subsequent maneuvering and fighting an incident occurred which alone would have sufficed

to keep the name of Balaklava in the history books: the charge of the Light Brigade on 25 October 1854. Military writers are still arguing who was responsible for this gallant but mad charge of all the British light cavalry into the Russian gun positions. The bravery of the men has been immortalized by Alfred Tennyson, Queen Victoria's poet-laureate, in the verses that have almost become a soldier's creed

> Theirs not to reason why
> Theirs but to do and die.

The losses were frightful, and criticism of the command arose in the homelands. Still the campaign progressed and on 5 November 1854 the battle of Inkerman was fought. It checked the Russian land army, which made no further immediate attempt to relieve Sevastopol. The British-French-Turkish forces had missed the chance, however, to take Sevastopol by quick assault, and they began to settle down for a siege.

The deceptive calm of pleasant autumn weather, akin to our Indian summer, had favored the campaign so far. But on the evening of 13 November heavy rain began to fall from a gray sky. A northeast wind swept over the allied encampment. The soldiers huddled for shelter in their tents. As the night wore on the wind increased, and by early morning it had turned into a lashing southeast gale which swept tents and bedding away. This was soon followed by violent westerly squalls and snow. Without fires and shelters, the allied army shivered in bitter cold.

The storm impartially disregarded army-navy rivalries. It had gathered its strength over the open sea and played havoc with the blockading fleet and supply vessels. Winds of hurricane velocity swept the western and southern shores of the Crimea throughout most of 14 November 1854 (Fig. 1). When the dismal day was over, the French had lost their finest battleship, the *Henri IV*, and the British supply fleet waiting to enter the harbor of Balaklava was wrecked. Nearly all stores were lost. Particularly painful was the sinking of the *Prince*, the finest steamer then existing. Her 7000-ton cargo of medical supplies, boots, and winter clothing, including 40,000 greatcoats, was at the bottom of the sea. This left the land forces facing a Russian winter in misery, starvation, and sickness.

The storm completely stymied any further military moves throughout the whole winter. The reactions to the disaster were vehement in England and in France. The plight of the soldiers led to private relief collections. The indescribable conditions of the hospitals were discovered and prompted the famous mission of Florence Nightingale. Here and there the most curious even raised the question whether the disastrous hurricane could have been foreseen. Before we let this question become mixed up with the political and military issues of the Crimean War it may be useful to take a look at the state of weather science 100 years ago.

People were still close to nature then. Farmers and sailors all knew their weather proverbs and made good use of them to forecast weather a few hours in advance. The old almanacs with their vague prognostications sold well. For more than 200 years the philosophers had watched the mercury column of the weather glass. The wise Benjamin Franklin had been well aware of the areal extent and migration of storms. The weather had been observed for many decades with barometers and thermometers. In fact, as early as 1780 the academies and philosophical societies had begun to cooperate to take weather records, and for several years (1781–92) they did so according to a common scheme. This remarkable endeavor in which most European and even some American learned societies participated was initiated by the Palatine

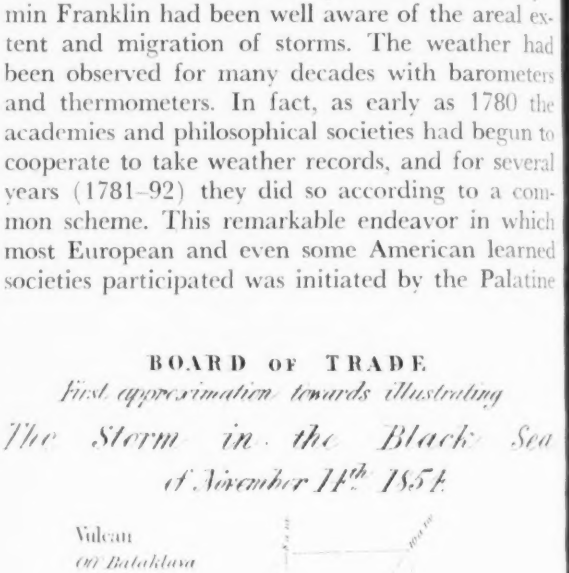

Fig. 1. Hodograph of wind observations of the storm of Balaklava made on a British ship off the harbor. The vectors show wind force and direction toward which the wind was blowing as functions of time. The drawing is a fragment reproduced from the large plate attached without text to the *Report of the Meteorological Department of the Board of Trade*, 1857. The original, presumably prepared by Robert FitzRoy, has wind diagrams and barometer readings for a score of ships of the British Black Sea fleet.

Meteorological Society at Mannheim, which also published all the observations in a series of big folios.

For three decades this material sat on the library shelves. It was a wonderful set of observations but, as with so many other collections of data, it remained unfinished scientific business. There was nobody to analyze the data. Finally in 1816 Heinrich W. Brandes of the University of Breslau in Prussia plotted the observations taken in 1783 for several widely separated places. He superimposed curves giving values of temperatures of each day for these stations. He also followed the coincident pressure and weather changes as they occurred across Europe. His work marks the birth of *synoptic* weather analysis, the method by which one can see at a glance weather observations taken simultaneously over a large area. In a book published in 1820, Brandes discussed his findings and stated quite succinctly that the various weather events seemed to be clearly connected with migrating systems of low pressure.

Here we had the big scientific discovery: a potent method for weather diagnosis. It went promptly back to the library shelves. Of what practical use was a weather picture some 30-odd years after the observations had been taken? Brandes was too far ahead of the technology of his time. His technique was almost forgotten, but the weather kept on plaguing the common man and continued to intrigue the scientists. Weather observations became more widespread over the globe.

At this point the scene shifts for a moment to the United States. About the time that Heinrich Brandes was beginning to analyze the 1783 data, it had become the prevalent notion in the New World that outbreaks of epidemics were related to weather. Thus in 1816 we find the Surgeon General of the U.S. Army issuing an order to all post surgeons to take meteorological observations. This was faithfully obeyed and files of meteorological registers accumulated in the War Department.

Twenty more years went by. A 25-year-old Yankee from Connecticut, Elias Loomis, occupied the chair of mathematics at Western Reserve University. The severe storm of 20 December 1836 prompted him to inspect all weather records for that date. In doing so he resurrected the Brandes procedure, and in 1841 he published a paper in the *Transactions of the American Philosophical Society* depicting progress of this storm. Soon thereafter William C. Redfield showed on a map the wind conditions of 15 December 1839, a date on which a severe storm had affected the northeastern coast of the United States; this map was published in the same *Transactions*. Then a tornado and another severe storm struck the Midwest in February 1842. Loomis analyzed the weather data for those and presented his findings to the Philosophical Society in 1843. He too plotted the data on a chart and drew lines of equal pressure, the now familiar isobars.

In the scientific world the synoptic weather map gradually became the accepted analytic tool for meteorological studies. Yet the collection of data from observatories and outposts was slow. It took months to get them to the laboratory. This was frustrating because it became clear to some of the meteorologists that the weather map not only was a means to diagnose the state of the weather but it could also be a guide toward prognosis. These pioneers of weather science were quite convinced that this new tool would be much superior to local observations of wind, clouds, and the barometer. None of these could indicate what was going on a few hundred miles away. But Loomis and his fellow-meteorologist James P. Espy of Pennsylvania had conclusively shown that big storms could travel hundreds of miles in a day. If the observations could be collected quickly in a central place, a forecast for a day or so in advance would become possible.

Fortunately, this time there was no need to store the good idea on the library shelves. The time was ripe. The electric telegraph had just been perfected to the point where the gathering of information from many points became possible. But the college professors had no access to the telegraph. The governments stood aloof from newfangled ideas. An enterprising newspaper, the London *Daily News* made the scoop. On 14 June 1849, the first weather map based on telegraphic messages was produced in England with the help of the meteorologist J. Glaisher. It was a one-time experiment, but it worked.

The telegraph in the service of meteorology intrigued the distinguished American physicist Joseph Henry, who had made many contributions to electric science. He had just assumed duties as the first secretary of the Smithsonian Institution in Washington. As one of the first programs to be carried on by this new institution, he instituted a system of weather stations on which forecasts could be based. A trial collection of weather data by telegraph was made in the New World too, but it was just a "dry run."

There was much academic interest in weather forecasts but not enough confidence in their possibilities to make them a feature of daily life. Things edged a little closer to that in 1851. A world exhi-

bition took place in London. One of the shows was a weather map which was produced daily from 8 August through 11 October. With the end of the exhibition public interest subsided and governments remained on the sidelines. But here and there the idea had struck imaginative minds. The French Meteorological Society talked at its 1852 meeting about a telegraphic meteorological service. In England the inspector general of fortifications, Sir John Burgoyne, thought meteorological information would help him in his metier, and he started a correspondence on the subject with an American naval officer, whom I shall introduce shortly. Sir John, incidentally, found himself 2 years later as chief engineer on the staff of General Lord Raglan, who commanded the British forces in the Crimea.

All the time the weather continued to plague mankind. Storms kept raising havoc and in no place worse than on the seas where the traffic density of clippers and rickety steamers had increased tremendously. Merchant marines engaged in worldwide commerce flourished under the watchful eye of expanding navies. However, the voyages were slow and tedious, and the perils of the gale-beaten seas were many. The sailors were the most weather-conscious people. Knowledge of winds and drifts meant livelihood and life to them.

A man of farsightedness and action rose from the ranks of the seamen, the American naval lieutenant Matthew Fontaine Maury. As head of the Naval Observatory in Washington, he saw the need for systematic meteorological and oceanographic observations. He prevailed upon his superiors to have the United States Government arrange with other seafaring nations to collect such data according to a uniform scheme. In 1853 an international conference was held in Brussels, Belgium, to discuss the problems of marine meteorology.

It was a meeting without precedent in international affairs. There were no diplomats. There was no jockeying for advantage. There were no secret agreements or protocols. The eminent meteorologists of the day, who had gathered at this conference, had little trouble in formulating their desires for marine weather observations and in agreeing on a set of rules for taking the readings. There was unanimity of opinion that the data should be freely exchanged between nations, because weather was no respecter of national boundaries or flags at sea. The suggestions of the conference were sent for implementation to the various governments who had sent representatives.

This required organization and funds. The whole thing was unheard of. Only one nation took prompt action. On 31 January 1854, William III, King of the Netherlands, issued a decree establishing a Meteorological Institute at Utrecht. A. C. Buys Ballot was placed in charge. He was one of the participants of the Brussels conference and a pioneer meteorologist. In 1848 he had started a meteorological observatory of his own, and in 1852 he had begun to plot charts showing day-by-day wind distribution in the coastal areas of western Europe. But in the big countries the ministries had little idea how to get going in this weather business. The politically powerful maritime interests kept prodding for action. Thus it was not difficult to secure some money for equipment to take the observations. We find that in England the parliament discussed the matter in February 1854 and voted the funds. In June of the same year the Board of Trade informed the Royal Society that a department of meteorology was to be established and asked for advice on the points in meteorological science to which attention should be directed. The Royal Society appointed a committee which took the matter under advisement. In September 1854 the office of the Privy Council of Trade formally asked the shipowners for cooperation in a letter which informed them that "Her Majesty's Government has submitted and Parliament has sanctioned a vote for instruments and tabulations of logs and other meteorological records."

In France interest in meteorology had been aroused in another quarter at the same time. Napoleon III's minister of war was a distinguished engineering officer, Marshal Jean Baptiste Philibert Vaillant, grand commander of the Legion of Honor. Among his many duties was the administration of Algeria. The varied climates of this territory created a lot of problems: the raising of crops, the proper uniform for soldiers, the water supplies, the mud-plagued road system, among others. Vaillant felt that meteorological information might help him in his task. On 21 April 1853 he addressed a letter to the French Academy of Science, of which he was a member-at-large. In it he requested advice on how to obtain weather data that would serve the enumerated practical purposes best. The academy referred the inquiry to a committee.

There things stood in the scientific world when the Crimean campaign started: Weather readings were being taken on land and on sea; the enthusiasts had demonstrated that the telegraph could gather at least the land observations, and these, when plotted on a map, yielded a picture of migratory storm systems; theories that would permit predictions on the basis of these weather maps were in the stage of formulation. But the public still relied on the almanac and the sailors on their experience.

Governments had no organizations to provide meteorological services, and committees of scientific elders were still debating whether there was anything more to meteorology than the keeping of a systematic record of weather.

Things might have dragged along for still more years in this fashion had not that fatal gale hit the Crimean shore. In England, with a free press, the outcry was immediate. In France the still shaky government of Napoleon III felt that something had to be done to soothe public indignation. On both sides of the Channel the wheels began to spin faster.

What happened in London? A month after the storm of Balaklava the Admiralty ordered Capt. Robert FitzRoy, Royal Navy, Fellow of the Royal Society, to "take charge of the measures necessary" to carry into effect the meteorological observations which "The Lord Commissioners of the Admiralty having, on the representation of the Royal Society, decided that her Majesty's ships" should participate in. Curiously enough his appointment was back-dated to August 1854. Under these orders Captain FitzRoy was seconded to the Board of Trade to take charge of the meteorological department. The select-committee of the Royal Society was still deliberating what this department should do while the political storm raged on the shores of the Thames. On 26 January 1855 Lord Aberdeen's cabinet fell, and Lord Palmerston succeeded him as Prime Minster. On 22 February the secretary of the Royal Society wrote a letter to the Board of Trade endorsing the meteorological observations. The epistle contained a cautious appraisal of meteorological knowledge; it ignored the storm of Balaklava; it neatly skirted the tricky question of forecasts but went at considerable length into the observational procedures that should be followed. However, the meteorological department of the Board of Trade was a fact now. It soon began to issue storm warnings in the port cities.

In France parliament, press, and public opinion had little to say at that time about affairs of state. It was the members of the dignified Academy of Sciences who became deeply involved in the weather-forecasting problem. We have already seen that in the previous year Marshal Vaillant, the Minister of War, had asked for some advice. The Balaklava storm was more than a matter of academic interest to him. He was responsible to the sanguine Napoleon III for the conduct of the war. The loss of the battleship *Henri IV,* the pride of the French navy, was a blow to the prestige of the regime. The Marshal was incensed by the dilatory treatment the academy's pomposity had given his earlier inquiry on meteorological matters. He wanted action. He got it from one of the most recent academicians to whom he wrote a letter right after the hurricane of 14 November 1854. In it he asked the astronomer Urbain Jean Joseph Le Verrier to undertake a study of the Balaklava storm. Was he not the man who had won undying fame by predicting the existence of another planet of the solar system just through pencil-and-paper work? Was he not in charge of the meteorological work at the Imperial Observatory in Paris, where he had just succeeded the famous Arago? If anyone could devise means to foretell the weather, Le Verrier was the man. Le Verrier had indeed a keen mind. He also had a sharp tongue and arrogant contempt for the work of others. He undoubtedly took delight in bypassing the official committee of the academy. Letters went forth from him to all European observatories with the request to send their weather observations for 11–16 November 1854 to Paris for a study of the Black Sea storm. Soon 250 answers were received, and Le Verrier put his meteorological assistant E. Lias to work plotting the data (Fig. 2). On the last day of January 1855, according to his later claims, Le Verrier told the academy that a storm warning could have been issued to the military forces in the Crimea a day in advance of the debacle. Strangely enough the transactions of the academy fail to note such a statement during the session of 31 January 1855. On 16 February Le Verrier submitted to "His Majesty the Emperor" a memorandum outlining a project for storm advisories. Napoleon approved at once. A cabinet order of the following day authorized Le Verrier to organize and operate a storm-warning service jointly with the director general of telegraphic lines. On 19 February Le Verrier announced to the academy the production of weather maps for France. The emperor kept prodding for a while. He had good reasons. During the same month a transport carrying 400 infantrymen was wrecked in a gale near Toulon.

The account could close here. The effect of the storm of Balaklava on the Crimean War and the ensuing political repercussions had brought the first governmental meteorological forecasting services into being. But it is of interest to relate that the enthusiasts for *telegraphic meteorology* had at least another decade of struggle ahead of them before things began to click. The story after Balaklava is nearly as intriguing as what went on before. First followed the animated debate in the French Academy of Sciences toward the end of 1855 when the committee finally reported on the meteorological network for Algeria, for which Marshal Vail-

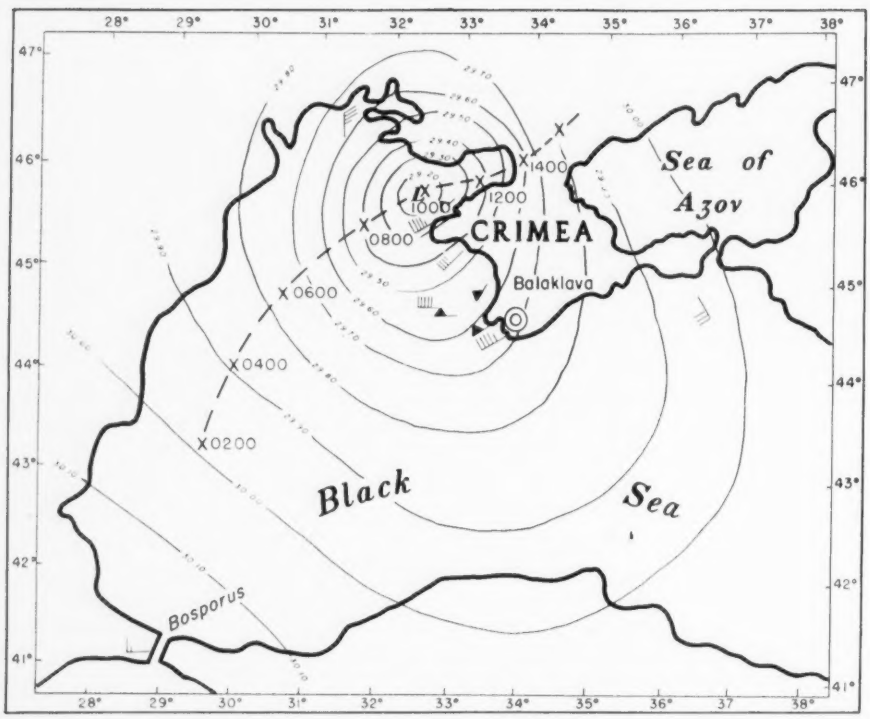

Fig. 2. Modern interpretation of the old data, showing the storm at its height on 14 November 1854 at 10 A.M. local time, and indicating the probable path of the storm center for 12 hr.

lant had asked. He was not too happy with it. The theoreticians wanted to have everything measured to a few decimal places but, heaven forbid, nothing of immediate practical use to the army. Vaillant and Le Verrier kept on plugging. The weather service spread. In 1861 telegraphic weather messages covered nearly all of Europe, and meteorological offices existed in all capitals.

Alas, the forecasts remained vague and not too reliable. Le Verrier had to face another attack in the academy in 1865, spearheaded by the Italian Matteucci. In England, after Admiral FitzRoy's death, a committee of the Board of Trade recommended in 1866 that the meteorological department continue its observations but abandon forecasting. In the United States, Maury was in eclipse because as a Virginian he had espoused the South's cause in the Civil War. But the idea of a daily weather forecast was too strong and public demand too insistent to permit even temporary interruption of a public weather service.

As we look back today we have to admit that it took considerable courage to interpret the sparse data of a century ago and flatly state that a forecast of the Balaklava storm could have been made. An attempt to analyze some of the old information, published a few years later by FitzRoy and Lias, will leave a modern meteorologist groaning. Unstandardized observations, unreduced barometer readings, no upper air data, and large gaps in the observational network make us realize that our predecessors were really enthusiasts and bold prophets. If we compare the situation in 1854 with the hundreds of surface and upper air observations we receive hourly over the teletype and think of storm detecting and tracking by radar, as well as hurricane reconnaissance by airplane, we can really appreciate the advances weather science has made during the last century.

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Perspectives and Horizons in Microbiology

The tenth anniversary of the discovery of streptomycin by Selman A. Waksman was marked on 7 June by the dedication of the Institute of Microbiology at Rutgers University. The new building was made possible by streptomycin, which has created a new industry. Royalties from the manufacture of the drug have amounted to more than $4 million, of which about 80 percent has been assigned to the Rutgers Research and Endowment Foundation. The objectives of the new institute, long ago stated by Waksman, include ". . . particular attention . . . to the fundamental aspects of the study of microorganisms, their physiology, their biochemical activities, and their relations to higher forms of life, notably man, and to his domesticated animals and plants." More than 400 leading scientists from the United States and abroad attended the dedication and took part in the 2-day symposium that followed. The dedication address and four of the papers are printed here.

Dedication of the Institute of Microbiology

LEWIS WEBSTER JONES

After serving as president of Bennington College and the University of Arkansas, Dr. Jones became president of Rutgers University in the fall of 1951. Prior to his academic career, Dr. Jones was an economist for the Foreign Policy Association. He has been a member of numerous boards and commissions of the Federal Government and is now chairman of the board of trustees of the Educational Testing Service and a member of the Ford Foundation Committee on Faculty Fellowships and a trustee of the Brookings Institution.

WE are met here to dedicate a building, this magnificent Institute of Microbiology, and to rededicate this university to the high purposes that this building symbolizes.

For Rutgers University, this is a proud and solemn moment. We recognize gratefully the work and achievements of one of the great creative personalities of our age and Rutgers' most distinguished son, Selman A. Waksman. He was educated at Rutgers, and most of his scientific work has been carried on here. His great abilities, his long and patient investigations, and his skilled and inspiring leadership have brought honor to his university and untold benefits to humanity. He has used the material rewards of his discoveries, with characteristic unselfishness, to further the scientific work to which he has devoted his life. This university gains immeasurably from the presence of this great international center of investigation and teaching and accepts with enthusiasm, gratitude, and resolution all the responsibilities it implies.

We welcome the scientists from many foreign countries who are with us. Their presence emphasizes the international tradition of science, worldwide in its scope and in the promise it holds for the destiny of the human race. The language of science is truly international, truly humane in its purposes. Science seeks to arrive at verifiable knowledge. In striking contrast to the struggle of rival propagandas that poison communication in the political sphere and erect impenetrable barriers between peoples, communication among scientists means a sharing of truth; all the evidence is carefully checked and openly presented for the common enlightenment. Scientific investigation is an expression of the continuing faith in human reason, in man's power to increase his dignity and stature by increasing his understanding.

In the dreary climate of the cold war, our vision of the future has been clouded, and its range sadly shortened by the fogs of doubt, fear, and suspicion. We can be thankful, as we contemplate this Institute of Microbiology, for the clear, bright pros-

The academic procession in front of the new building. Marshal of the procession is Albert E. Meder, Jr., dean of administration of Rutgers University. He is being followed by the staff of the institute and the university senate.

pect it opens before us. We can be sure that the work that will be done here will be more significant, more far-reaching, and infinitely more creative and enduring than the political events that fill today's newspaper headlines.

This institute will be hospitable to scientific workers and students from many lands and from many related fields of investigation. We are dealing here with the most constructive powers of the human mind; and the creative imagination of the scientist links him in a common fellowship with artists, poets, philosophers, and all men of learning and good will, with all, indeed, who share the aspirations of the spirit.

This will be a place where the imagination of gifted individuals will have full scope; where teams of scientists can pool their resources for the advancement of knowledge. It will give mature workers an opportunity for continuing achievement and younger workers a chance to learn and develop their skills. It will be mainly concerned with basic investigations into the nature of microorganisms as well as with the many and varied applications of newly discovered knowledge. It will be truly productive, in a world too much threatened with destructive forces: productive of understanding, enlightenment, and practical human welfare.

We therefore dedicate this building, and rededicate this university, to the enduring values on which our civilization rests: the search for knowledge and understanding and its humane use under the guidance of universally applicable ethical principles. We thus reaffirm our faith in reason and good will and our hope for the future.

Microbiology Takes the Stage

SELMAN A. WAKSMAN

Preceding his appointment as director of the Institute of Microbiology at Rutgers University, Dr. Waksman had a long and illustrious career in university teaching and experimental research. He has also served as consultant to several Federal Government, scientific, and industrial organizations and is the author of several hundred scientific papers and 15 books. In collaboration with his students and associates, he has isolated at least 11 new antibiotics, chief of which are streptomycin and neomycin. He was awarded the Nobel prize in medicine and physiology in 1952 and has also been the recipient of many other awards and honorary titles. Out of the small portion of the royalties assigned to him personally from the manufacture and sale of streptomycin, he has established the Foundation for Microbiology for the support of research and publications in this field at various institutions. He and Mrs. Waksman have also established a scholarship for an immigrant student at Rutgers.

THE first institute devoted primarily to microbiology, named after Louis Pasteur, was dedicated two-thirds of a century ago, 14 November, 1888. At the time of its organization, the staff consisted of Pasteur as the director; Duclaux, in charge of general microbiology; Chamberland, concerned with microbiology in relation to hygiene; Roux, studying microbiological methods in their medical applications; and Metchnikoff, working in the general field of morphology of lower organisms and comparative microbiology.

These investigators were interested primarily in

the relation of microorganisms to human health and the causation of disease. General microbiology, systematics of microorganisms, and microbial physiology and biochemistry occupied only a secondary place. Microbial genetics and cytology were hardly considered. The broad aspects of the role of microorganisms in the cycle of life in nature and in soil processes and the wider problems of chemotherapy were not yet contemplated.

We have come a long way during the past few decades. There is no field of human endeavor where microbes are not recognized now as playing an important, and frequently a dominant, part. We can now recognize, utilize, combat, and in most cases control the numerous microbes that cause infectious diseases and epidemics, attack our animals and our plants, destroy our food supplies and our clothing, inhabit our soils and our seas, the air we breathe, the water we drink, and even our bodies. We also have learned to know microbes as complex living systems. We now understand better their growth and their functions, their manner of multiplying, and of utilizing simple and complex nutrients, and we have gained considerable information concerning the complex biochemical reactions involved in these processes.

We have learned much about the life of microbes in pure cultures and in complex populations and the production by many of them of specific chemical substances which stimulate or inhibit the growth of others. We have learned also to utilize such substances for improving and accelerating the growth of higher forms of life, for destroying injurious microbes, thus improving human and animal health. Diseases and epidemics that formerly decimated huge segments of the world's population have now been brought under control, deaths due to diseases of childhood are now relatively rare, and the life-span of man has been greatly extended.

How has all this been brought about? What have we learned that will help us to plan our future investigations? To what extent has the microbiologist benefited from the contributions of the general biologist? In what respects do the methods of studying bacteria, fungi, actinomycetes, and protozoans differ from the methods of studying higher forms of life, both plant and animal? Are the tools, the methods, the approaches, or observations used in the study of microbes different from those employed by the general biologist?

These and many other questions that pertain to the world of microbes in which we live have been only partly answered. Many questions still await the investigator. These problems are fundamental in nature, but the answers promise rich rewards in practical applications. Many questions have remained unanswered because the proper methods of investigation have not yet been discovered. We are dealing with microscopic and ultramicroscopic forms of life, which we often recognize not by what they look like but by what they do; not by how they behave in a normal environment, but by how their reactions in an abnormal environment can be interpreted in terms of their life-processes and role in the cycle of life in nature.

Claude Bernard emphasized the fact that reasoning is correct only when applied to correct facts; when facts are originally tainted with error and inaccuracy, reasoning based on them can lead only to error:

> The art of investigation is the cornerstone of all the experimental sciences. If the facts used as a basis for reasoning are ill-established or erroneous, everything will crumble or be falsified; and it is thus that errors in scientific theories must often originate in errors of fact.

If this applies to higher forms of life, it applies with even greater force to the life of the microbes. Bernard stated further:

> The investigator must be at once a theorist and a practitioner. He must completely master the art of establishing experimental facts, which are the materials of science, and he must also clearly understand the scientific principles which guide his reasoning through the varied experimental studies of natural phenomena. Head and hand must go together. An able hand without a head to direct it is a worthless tool; the head is powerless without its executive hand.

We can subscribe heartily to these principles. Pasteur himself said at the dedication ceremonies of his institute:

> My dear collaborators, keep your enthusiasm, but let its inseparable companion be rigorous control. Do not advance any idea which cannot be proved in a simple and decisive manner. Cultivate the critical spirit. In itself, it is neither a provoker of ideas nor a stimulant to great things. It always has the last word, however.

There has been much elaboration on Pasteur's dictum, "Chance comes only to the prepared mind," or as Nicolle expressed it, "Chance favors only those who know how to court her." Helmholtz said, "Happy ideas come unexpectedly without effort, like an inspiration. So far as I was concerned, they have never come to me when my mind was fatigued, or when I was at my working table. . . . They came particularly readily during

A view of the building of the Institute of Microbiology at Rutgers University.

the slow ascent of wooded hills on a sunny day." The poet Byron expressed it in somewhat different terms: "To be perfectly original one should think much and read little, and this is impossible, for one must have read before one has learnt to think." Theobald Smith emphasized that "discovery should come as an adventure rather than as the result of a logical process of thought."

The ability of the investigator to discriminate is another aspect of the method of discovery that has often been neglected. It may not be so spectacular as chance, but it is more certain to bear fruit. This was well expressed by Hans Zinsser:

> The scientist takes off from the manifold observations of predecessors, and shows his intelligence, if any, by his ability to discriminate between the important and the negligible, by selecting here and there the significant stepping-stones that will lead across the difficulties to new understanding. The one who places the last stone and steps across to the *terra firma* of accomplished discovery gets all the credit. Only the initiated know and honor those whose patient integrity and devotion to exact observation have made the last step possible.

Paul Ehrlich emphasized the need for "much testing, accuracy and precision in experiment, and no guess work or self-deception."

To envisage the progress of science, we may again refer to Bernard, who pointed out that

> . . . new ideas and discoveries are like grains: it is not sufficient to produce them and seed them; they must be nourished and allowed to develop by means of scientific culture. Otherwise, they die or emigrate to other places where they are found to prosper and bear fruit wherever they find fertile soil, often far away from the place of origin.

Also, he emphasized that "men who have excessive faith in their theories or ideas are not only ill-prepared for making discoveries, but they also make poor observations."

The scientific method is clearly outlined by Walter B. Cannon in *The Way of an Investigator*. He says:

> Curiosity has been condemned as a disease and as a low vice, and theologians and poets have solemnly warned against it. But in spite of the testimony that it was curiosity which lost us paradise, I am sure that all who are aware of the fruits of the tree of knowledge would agree that they have become abundant because of the spying and trying of inquisitive scientists. . . . [The investigator] sees events and changes in his field which seem to him strange and mysterious. Instead of ignoring them, as most people do, he wonders about them and sets to work to learn their characteristics. Curiosity is the main-spring of his initiative and his persistent industry. It is a prime requisite for a career of exploration.

The investigators themselves deserve particular attention. In his introduction to Max Planck's *Where Is Science Going*, Einstein emphasizes that there are

> . . . many kinds of men who devote themselves to science, and not all for the sake of science itself. There are some who come into her temple because it offers them the opportunity to display their par-

ticular talents. To this class of men science is a kind of sport in the practice of which they exult, just as an athlete exults in the exercise of his muscular prowess. There is another class of men who come into the temple to make an offering of their brain pulp in the hope of securing a profitable return. These men are scientists only by the chance of some circumstance which offered itself when making a choice of career. . . . Should an angel of God descend and drive from the Temple of Science all those who belong to the categories I have mentioned, I fear the temple would be nearly emptied. But a few worshipers would still remain. . . . For most part they are strange, taciturn and lonely fellows. And, in spite of this mutual resemblance, they are far less like one another than those whom our hypothetical angel has expelled.

This brings me to the methods of educating scientists. I am not primarily concerned with secondary or even undergraduate college education. I have in mind graduate training, the education of the future scientist after he has definitely decided upon a field of work and often even upon a type of problem, or at least upon a method of approach to a problem.

Some educators fill the candidate with information. In time, they make him feel that he knows all there is to be known about a certain field of science, and sometimes all that will ever be known about a given problem or the approach to the problem. This is, of course, the way to the "expert," the object of hero worship, and often even to the mystic in science. Other educators make the candidate feel that he knows only very little, in fact, that no one knows very much in a given field of science, and that the future lies before him to be investigated.

The first method is by far the more satisfying to the student. He completes his work with a feeling that he is a master of the subject, that he is now prepared to teach others and often even to show off to others his brilliant knowledge. The second method is the more difficult one, the less acceptable to the student, and often the more discouraging. The student who manages, however, to survive this type of training is the more humble in his approach to the unknown universe; he is more inclined to continue the seearch for more information. This approach to the education of a scientist reminds me of the story told by Morris R. Cohen: "As a teacher," he said, "one must clear the ground of useless rubbish before one can begin to build." When reproached by one of his students for his destructive criticism, he replied: "You have heard the story of how Hercules cleaned the Augean stables. He took out all the dirt and manure and left them clean. You ask me, 'What did he leave in their stead?' To this, I answer, 'Isn't it enough to have cleaned the stables?' " I am afraid that while this reply may have satisfied students in philosophy, it would hardly have done so for students of the experimental sciences, certainly not for the great majority of them.

An extreme of the second method of education is illustrated by the story told of Wilhelm Beijerinck. Upon entering the laboratory one morning, he found one of his students staining a bacterial preparation. When he asked the student the nature of the stain that he was using, the reply was: "Gentian violet." Beijerinck then proceeded with a question concerning the chemical structure of the stain. The confused student pleaded ignorance. Beijerinck commented caustically that an investigator had no business to carry out research by the use of tools the nature of which was unknown to him.

What about the relation of the scientist to his environment? On the one hand, we have the concept of Emil Roux, a former director of the Pasteur Institute, who believed that a scientist should devote the whole of his life to science, should not possess a private or personal life, should not even marry; no wonder that he was often spoken of as "moins laique" or "lay monk." On the other hand, we have the concept of the true biologist, who sees in all human lives a constant adjustment to the environment. This is well expressed by Raymond Pearl:

> Because a person, from however pure and noble motives, elects to be a worker in science he is not thereby absolved from the duties and privileges of being human. He must work out an adjustment between the claims upon his life by his science, a proverbially jealous and exacting mistress, and those of the rest of the world, including not only deans, committees, commissioners, directors, boards, foundations and other great cosmic elements, but also cooks, maids, nurses, children, and most important of all, his wife. If our graduate student, in whose behalf we are taking all this trouble, turns out to amount to much he will sooner or later receive offers for the purchase of his soul. Such offers will be made by those skilled in the traffic and they will be tempting. Shall we not be derelict in our job of helping our student to get his training for life if we do not furnish him some insight into what wisdom is available about the making of these necessary adjustments between scientific research and the rest of life?

We are now faced with the problem of selecting a group of scientists who will come to the Institute

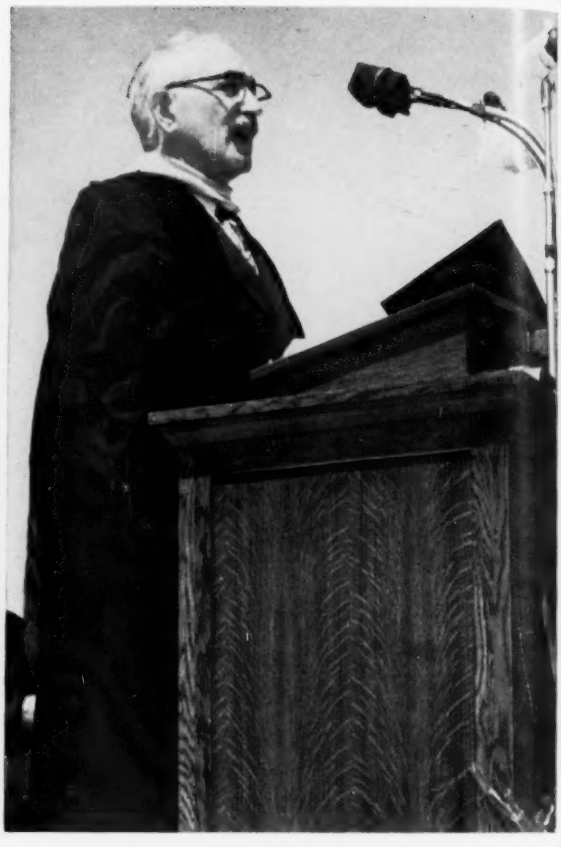
of Microbiology and who will labor to advance our knowledge of microbes. There are, of course, those who have already established themselves, who have already demonstrated their ability to contribute to this search of the unknown. There are, on the other hand, those who are still young and inexperienced, but who, given the proper opportunity, will develop into brilliant investigators. But how is one to select the latter? We can only think of the most delightful conversation that took place in 1813 between Sir Humphry Davy and his friend Pepys: "Pepys, what am I to do? Here is a letter from a young man named Faraday. He has been attending my lectures, and wants me to give him employment at the Royal Institute—what can I do?" "Do?," said Pepys, "put him to wash bottles; if he refuses he is good for nothing." "No, no," replied Davy, "we must try him with something better than that."

Should one decide upon such promising young investigators, one should think at once of the admonition given by Charles Richet in his *Natural History of a Savant*:

> Young man, if you would discover a new truth, do not seek to know what use will be made of it. Do not ask in what way medicine or commerce or industry may profit by the discovery; for if you do, you will discover nothing at all. You wish to find a solution to a problem that you consider important: tackle the problem without worrying about the consequences. Attack the question on its simplest side. Do not be stopped by the criticisms of journalists, hygienists, engineers, chemists, doctors. Let them talk. Go straight to the problem by the shortest road. Leave the practitioners the cumbersome care of consequences and industrial applications. *Veritas lucet ipsa per se.* Truth is sufficient unto itself.

The time when a Faraday could make a great discovery merely by using a piece of string and copper wire and working in a cellar has long passed. The modern chemical and biological laboratories require expensive equipment. The research problem frequently involves the collaboration of several investigators and certainly that of the senior investigator and his assistants, the teacher with his long and varied experience, and the student who has come to be taught and guided and to benefit from such experience.

The question frequently arises of how to distribute the credit for a new discovery, a new fact, a new observation. Some investigators will credit their assistants merely by footnotes on scientific papers; others will exert every effort to encourage their students, inspire them and stimulate them further to select research careers, and in doing so,



Waksman delivering his dedication address.

may not only add their names to the scientific papers but even place them first. In most cases, the results of the second practice are entirely satisfactory. Often, however, the consequences are most unexpected. How should one strike a happy medium? Scientists are searchers of truth. But they are also human beings.

Lately we have been hearing a great deal about the concept of "pure" or "basic" and of "applied" or "practical" research. One is supposed to designate the study of fundamental principles underlying any natural phenomena; the other is supposed to designate the use for practical purposes of information thus gained. A German investigator who died recently is said to have commented: "I am dying happily with the knowledge that out of my 50 years of research not one of my discoveries has found any practical application." Personally, I prefer the concept of Pasteur, who emphasized that science and the applications of science are related to each other as are the fruits to the tree that bears them. In the words of Pasteur:

> When one has reached the certainty of having discovered an important scientific fact, one ex-

periences the greatest joy that can be felt by a human soul, and the thought that one has contributed to the honor of his country makes this joy even more profound.

It is my sincerest hope that while the workers in this institute will concern themselves with the search for truths basic to our knowledge of microbes, their nature, their occurrence, their manifold activities, and their role in natural processes, they will not overlook any potential utilization of facts thus obtained for improving our health, combating our natural enemies, increasing the productivity of our mills and our fields, and advancing other aspects of human welfare that will go to make the life of man easier, better, and happier.

The functions of this institute will comprise both research and teaching, largely on graduate and postdoctorate levels. The staff of the institute will offer courses in the various fields of microbiology to graduate students and will conduct seminars for graduate and postdoctorate students. These courses will also include supervision of various research problems, in both the fundamental and the applied phases of the subject. The institute will serve as a gathering place for seminars and conferences on microbiological subjects. It will also serve as a depository of cultures of microorganisms of theoretical or practical importance.

In planning this institute, departmentalization has been avoided. It is our sincere hope that research programs will be flexible, investigators will be free to pursue their chosen fields without restriction, "team research" will be encouraged whenever possible, especially when "it grows out of genuine supplementation of contributions" and "when it serves the purpose of developing ideas" (Curt P. Richter). Opportunities will be given younger men and women to obtain knowledge and guidance in these selected fields.

I would like to repeat what I said 2 years ago, in connection with the laying of the cornerstone of this building: This institute will devote its efforts to the study of the smallest forms of life, the microbes, wherever they are found and no matter what their activities may be. Let this institute serve as a center where scientists from all parts of the world may gather to work, to learn, and to teach. The halls of this institute are dedicated to the free pursuit of scientific knowledge for the benefit of all mankind.

A Tribute to Rutgers University and the State of New Jersey

ALBERT J. KLUYVER

Dr. Kluyver, who is a recognized world authority in the field of microbiology, holds a professorship at Technical University in Delft, Holland. He is a past president of the Royal Netherlands Academy of Sciences. This article is a condensed version of Dr. Kluyver's address.

CLOSE ties have, from the very beginning, linked Rutgers University with the Netherlands. The name Rutgers immediately suggests that at some time there must have been an intimate relationship between this institution and a man of Dutch descent. True, the great philanthropist Henry Rutgers, who in 1825 at the age of 80 succeeded in acquiring immortality by his, for those days, princely gift of $5000 to Queen's College, was born in New York. But the name Rutgers—unpronounceable for the Anglo-Saxon tongue—leaves not the slightest doubt regarding the origin of his ancestors. Even nowadays descendants of the patrician family Rutgers enjoy great esteem in Holland.

Apart from the university's name, there is also the donation made in 1927 by the Holland Society of New York: the fine statue of William the Silent on the campus, which testifies to the fact that also in later years the university has been fully aware of the important part Dutch settlers played in its foundation.

Both the university's name and the statue are, however, mere symbols of the good relations that have existed between the State University of New Jersey and the Netherlands. A more convincing testimonial to this bond can be found in the fine history of Rutgers College published in 1924 by the former president, William H. S. Demarest. The first chapters, dealing with the origin of the

college, solidly document the fact that the initiative for its foundation was taken by settlers of Dutch descent, in close consultation with the Dutch Reformed Church. Demarest says regarding these settlers:

> The college is a child of their fine tradition, their zeal for education, their devotion to the faith, and of the compelling circumstances in their new American life.

I feel fortunate that I can quote from such an authoritative and unbiased source, since a perusal of the book has taught me that not all my fellow-countrymen have under all conditions been favorably disposed to the idea of founding a new center of learning in the New World. Particularly, the Classis of the Dutch Reformed Church at Amsterdam seems to have opposed the project rather vigorously, fear of the necessity of financial support from the homeland apparently being at least partly responsible.

But the indomitable spirit of the pioneers finally overcame all obstacles, and in 1766 Queen's College was chartered. In this first era, Dutch influence remained considerable. At that time the activities of the college were mainly restricted to those of the theological seminary, and many of the professors had studied in the Netherlands and received their degree of doctor of divinity at one of the Dutch universities. Probably the last one to do so was the former president, John H. Livingston. At the University of Utrecht, a bronze tablet reared in 1909 by the trustees, faculty, alumni, and friends of Rutgers College commemorates their appreciation for the part the university has played in the cultivation of Livingston's scholarship. The inscription refers to the University as "Mater Almae Matris Nostrae."

The Institute of Microbiology is a direct outcome of the great heights that agricultural science has attained at Rutgers University. In turn, this is clearly connected with the high level of agriculture and horticulture in New Jersey, which earned it the epithet "Garden State." It seems appropriate to review briefly some of the events that led to the establishment of the present state of agriculture in New Jersey and the establishment of this institute.

Carl R. Woodward has sketched an interesting picture of agriculture in New Jersey in the monograph entitled *New Jersey: A History* (1930). By 1630, several Dutch farmers had settled on the west bank of the Hudson River and established plantations or "boueries," as they were then called, a word which, strangely, still survives as the name of one of Manhattan's slums. A Dutchman by the name of Pauw obtained title to the greater part of the territory now known as Hudson County, at that time called Pavonia after him. He must have developed his holdings energetically and successfully, for in 1632 it was reported that the "boueries" on the west side of the river were in a prosperous condition, the settlers growing grain and raising cattle and poultry. Many of these settlements were, however, wiped out by the Indian massacres in 1643 and 1654, only to be revived in 1660, better precautions being taken against Indian raids.

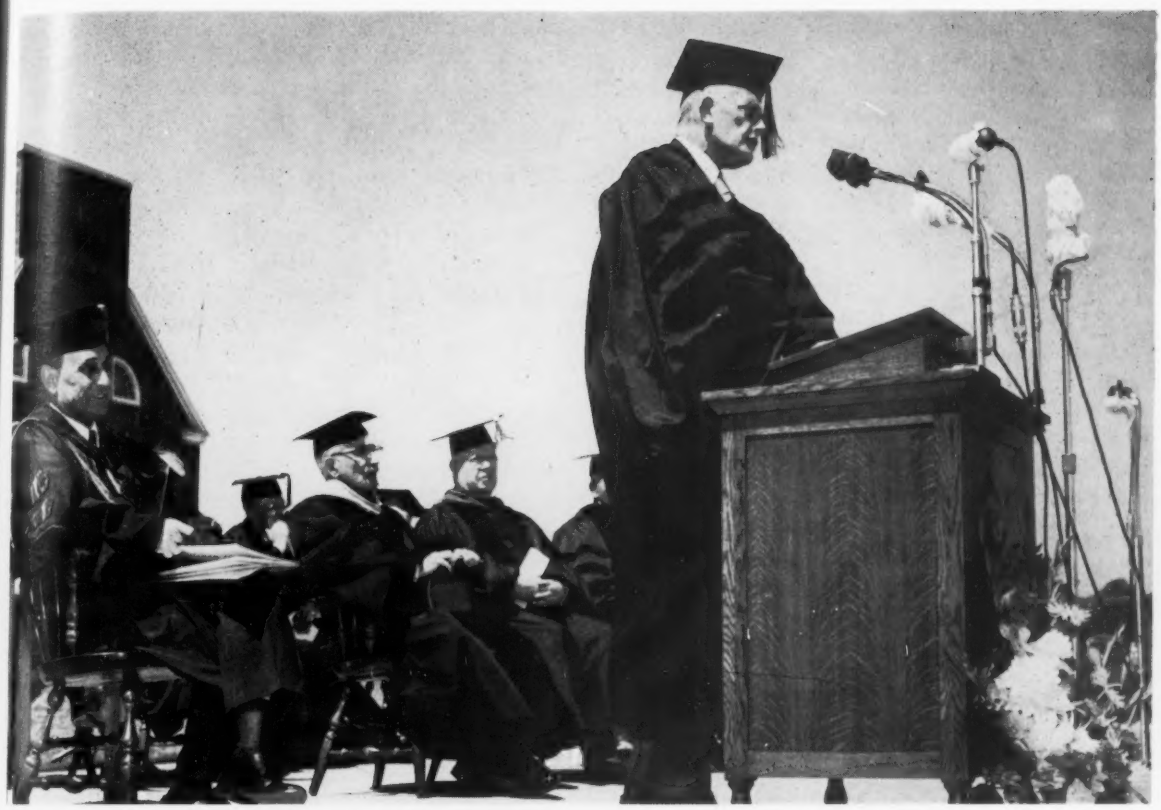
With the passing of New Netherlands to English control, the Dutch moved inland along the river courses. Among these, special mention is made of the Raritan, and it seems likely that the very spot on which this new building stands once formed part of one of the farms that in 1680 were reported as "very fine and yielding well."

Woodward gives a long list of the vegetables, fruit and flower plants that were imported in the 17th century by the settlers from the Netherlands and that thrived exceedingly well in the fertile New Jersey soil. Woodward adds that "the Dutch were the first people to grow the European grains in the New World on a profitable commercial basis," and refers in this connection to wheat, rye, and barley. He finally states that to the Dutch goes credit also for the early introduction of the best foundation stock of horses and cattle. He further mentions the importation of hogs and numerous types of domestic fowl.

Altogether, I do not think I go too far in concluding that Dutch farming experience, and plants and animals of Dutch stock, were mainly responsible for laying the foundations on which rests the well-deserved fame of New Jersey as the "Garden State."

The development of the agricultural sciences in New Jersey can be said to have started in 1864 when the state assigned to Rutgers College the responsibilities and benefits of the Land-Grant Act of the Congress of the United States. Rutgers has responded nobly to this assignment. In 1939, Waksman, in his article entitled "Cook-Voorhees-Lipman: contributions of Rutgers to soil science," paid warm tribute to the eminent scientists who earned a world reputation for the New Jersey Agricultural Experiment Station, the organization in which the Rutgers efforts in this field have been channeled since 1880.

As early as 1895 Edward B. Voorhees started investigations of soil microbiology and in 1901 established a separate Department of Soil Chemistry and Bacteriology, the first of its kind in the



Kluyver speaking at the dedication ceremonies on the grounds in front of the Institute of Microbiology.

United States. In view of the present-day emphasis on biochemical studies in microbiology, it is worth mentioning that the first Nichols gold medal of the American Chemical Society was awarded to the bacteriologists Voorhees and Steel for their paper entitled "Studies in denitrification."

The initiative taken by Voorhees was magnificently carried on by Jacob G. Lipman, who in 1911 succeeded him as director of the Experiment Station. Outstanding among the many great merits of Lipman, was his clear recognition of the vastness of the domain that in soil microbiology was still waiting scientific exploration. He made several valuable contributions to our knowledge of the microflora of the soil and, in numerous reviews and books, did a great deal to stimulate interest in the field. In the outstanding journal *Soil Science,* which he founded and of which he was editor in chief until his death, he erected an imperishable monument to himself. Finally he proved his great wisdom in the selection of collaborators worthy of the high reputation of the Experiment Station. Among these are Selman A. Waksman, who entered the station in 1918 and who succeeded Lipman after his death in 1939, and Robert L. Starkey, who joined his staff in 1926. The highly important work they have done has made the New Jersey Agricultural Experiment Station the mecca of soil microbiologists from all over the world. Characteristic of the way in which the problems of soil microbiology have been attacked here is the purely scientific spirit in which the investigations have been conducted. Increase of knowledge of the microbe world in its divergent manifestations has been the leading principle.

Studies of this type usually fail to impress the general public, but Waksman's fame among microbiologists dates back to a time long before the words *antibiotics* and *streptomycin* were coined. Pasteur once remarked: "Le hasard ne favorise que les âmes préparées"—chance favors only those who are prepared, and it is quite clear that this dictum also applies to the great discovery of streptomycin. If Waksman had not made such extensive studies on the actinomycetes as long ago as the 1910's, in a period in which almost no one had any interest in this microbial group, and if he had not so thoroughly investigated the fate of certain microbes in the soil, thus throwing a clear light on the chemical warfare in which so many microbial

types are continuously engaged, he could not have discovered streptomycin.

For this reason the microbiologists of the world wish to honor Waksman above all as the disinterested man of science who for almost 40 years has made so many important contributions to pure microbiology. But in addition, we do not lack in admiration for the great ingenuity and the exemplary perseverance with which he pursued his studies as soon as it became clear that microbial antagonism could be directly applied to the alleviation of the sufferings of mankind. Nor can we fail to express our deep appreciation for the fact that he has directed certain material consequences of his work in such a way that they resulted in the splendid Institute of Microbiology.

The prospects of the new institute seem bright. It has been designed and equipped by a man who won his spurs in the field. Moreover, the same man will be its first director and determine its course. Anyone who has read the recent article on the man of 65 in the British medical journal *Lancet,* will agree with its general conclusion: "do not put him on the shelf." On the contrary, realizing how greatly our standard of old age has changed in recent decades, we are certain that Waksman's accumulated wisdom will prove to be an invaluable asset, and to his guidance we all look forward with the greatest confidence.

In the name of the microbiologists of all nations I herewith offer to the new Institute of Microbiology our very best wishes for its lasting prosperity. The institute has been born of microbial antagonism. May it forever be a symbol of human symbiosis, and may it flourish to the benefit of our beloved science and of mankind as a whole.

In concluding, I may perhaps formulate one more wish. John H. Livingston, inspired by the motto of the University of Utrecht, "Sol justitiae illustra nos," chose as the motto of Rutgers University, "Sol justitiae et occidentem illustra." May the time not be far off when the sun of righteousness will shine equally bright upon both Occident and Orient.

Science of Microbiology in the Future

JACQUES TREFOUEL

Dr. Trefouel has been associated with the Pasteur Institute in Paris since 1920, first as professor and now as director. He has made important contributions to the chemotherapy of bacterial diseases and especially to the development of the sulfonamides.

THE rapidity with which the science of microbiology has developed within the last century is more than remarkable, and the past offers unlimited hope for the future.

Three illnesses are of prime importance today: tuberculosis, the virus diseases, and cancer. The first of these has come almost within our control. The important role played by Selman A. Waksman in the achievement of this wonderful victory is well known to all of us. The sulfones have been used with considerable success in the treatment of leprosy caused by another acid-resistant bacillus, that of Hansen. These results permit us to hope that the existence of this dread disease will become more and more rare.

Certain virus diseases have been favorably influenced by chemotherapy, but many others have not yet given positive results. It is this lack of results that has led many scientists in laboratories throughout the world to concentrate a large part of their energy on this problem.

We at the Pasteur Institute have just opened a special service for the study of yellow fever under the direction of Panthier. Also, a generous donation enabled the Pasteur Institute recently to transfer the virus division to a new, specially constructed building, which houses the most modern group of laboratories in Europe.

The virus division, directed by Pierre Lepine, is devoted to the study of problems created by viruses in man and animals. The Pasteur Institute continues a tradition of research which, born of the work of Pasteur, Roux, and Chamberland on rabies, has been firmly established as an independent science from the time of Borrel's and Levaditi's first researches on virus. This study that will take place at the Pasteur Institute cannot be better described than in the words of Lepine:

Although the origin of this research, as well as its aim and purpose, consists of the study of virus diseases and the prophylaxis of infections caused by them, research work is carried out along three parallel lines: (i) epidemiological and immunological study of disease in order to arrive at prevention, generally by means of vaccination; (ii) histopathological and descriptive study of specific characteristic lesions, with which has been connected in recent years morphological study of pathological cell structures with the electron microscope; (iii) physiological, physical, and chemical study of the virus itself, a study concerned with the cellular metabolism of the host-cell, the composition and requirements of the virus, resulting in its culture in mediums and on adapted cells, which, along with theoretical study, may permit the preparation of antigens for serological reactions or may provide the raw material for a vaccine.

These three branches of virus research, although they are carried out separately, cannot be dissociated, for their results overlap and are mutually dependent. Knowledge of the disease in laboratory animals allows one to foresee the requirements of the virus. Morphological study of lesions gives the key to the evolution of the virus. Academic research on the virus has its application in the prophylaxis of the disease caused by the virus. Carried out by workers forming different teams but keeping in close contact and exchanging their results, these three lines of research complement and control one another.

It is impossible to study chemical immunology without purified antigens. To use the electron microscope without a knowledge of host-cell interrelationships is to condemn oneself to a static and sterile morphology. To study the behavior *in vitro* of the virus, its metabolism, and its rhythm of multiplication without contact with epidemiology is to lose sight of the real and forget that in the laboratory one works only with domesticated species leading an artificial life.

The subjects that are today the object of study of the virus research division are essentially poliomyelitis, neurotrophic viruses, and tumor viruses.

The work on poliomyelitis is a continuation of the work begun in 1909 with the demonstration by Levaditi and Landsteiner of the filterability of the virus, followed by the discovery of specific antibodies in man in 1912 by Netter and Levaditi; the culture of the virus *in vitro* on fibroblasts by Levaditi in 1913; the demonstration of Kling's theory of digestive transmission in 1928 by Levaditi and Lepine; the first attempts at vaccination on monkeys with living attenuated virus by Lepine in 1934; the first therapeutic and prophylactic experiments upon the action of *Daboia* snake venom in 1949. Recent work of importance includes that of Enders on virus culture, the adaptation of human tonsil tissue for the culture of poliomyelitis virus, and very recently the simplification in the titration of the three types of antibodies by the method of culture on molded plastic plates.

The research on neurotropic viruses included work on rabies, with the application of hyperimmune serum to its prophylaxis, and the work on encephalitides, particularly those on tropical origin, more especially those of the African group.

These various researches, especially those on rabies, are carried out in close association with the World Health Organization, with whose program the virus division of the Pasteur Institute is working in complete cooperation.

Research on tumor virus was begun more recently. It has opened the door to a domain in which are intermingled the problems of virus and of cancer. We think that here is a future path.

Work with animal leukemia such as that caused by fowl or mice virus gives us unexpected glimpses into the relationships between genetics and sensitivity to virus as well as into the different histopathological forms of tumors that the same virus can cause in closely related zoological species.

Still more curious is the work on choriotropic virus, which, isolated by R. de Ruyck from hydratic moles of women, has been found to be transmissible to the animals and titratable by hemagglutination. This virus, which shows a remarkable affinity for the reticuloendothelial system and causes indisputable malignant tumors, presents physical and chemical characteristics that make it one of the most interesting viruses to study.

Thus the work of the virus division of the Pasteur Institute is contributing to the academic and practical study of a rapidly advancing branch of microbiological science.

I have asked Jacques Monod, who is very well known here in America, to inform you of his ideas on the service of enzymology at the Pasteur Institute. In his words:

> Microbiology developed for a long time as a largely autonomous science with its own problems and its own methodology. For the last 20 years, however, it has tended to merge more and more with other biological disciplines, and the contributions made by microbiology to the solution of fundamental biological problems have been steadily increasing.
>
> The physiology of microorganisms is actively studied today, not only because of the interest and

A visit to the Squibb Institute for Medical Research was a feature of the dedication ceremonies. Left to right: Waksman, A. F. Langlykke, director of research at the Squibb Institute, Mrs. Trefouel, Mrs. Waksman, and Trefouel.

extreme importance of these organisms, but also and very largely because they constitute one of the most favorable materials for the study of the fundamental processes of life, from the simpler biochemical reactions to the reproduction and multiplication of cells.

This tendency toward a generalization of microbiology first became especially clear in connection with studies of nutrition. I hardly need to emphasize here that the most efficient and widely used method for the study and identification of vitamins in human nutrition is the analysis of growth requirements of certain microorganisms. I may also perhaps be permitted to recall that the discovery of the sulfonamides as antibacterial agents and the study of their mode of action eventually led, by a series of developments, the logic of which is perfectly clear today, to the identification of an important vitamin—para-aminobenzoic acid.

The increasing importance of microbiology and of microbiological material in the development of biochemistry may be considered both the cause and the result of the most marked tendency of modern biochemistry, namely, the emphasis on biosynthetic processes. Biochemistry in its early days was essentially an analytic science. Beginning in Pasteur's time, and largely through his influence, interest in the dynamic aspects of biochemistry gradually became prevalent. Only recently, however, has it become possible for biochemistry to attack the problems of the biosynthesis of characteristic biological compounds. Tremendous strides have been made very rapidly in this direction, and the biosynthetic pathways of many essential compounds have already been largely elucidated. However, the most formidable problem, the biosynthesis of high-molecular weight compounds, such as proteins and nucleic acids, has only begun to be tackled.

Yet this is one of the most important biological problems, and it is precisely the type of problem to which microbial biochemistry can make the most significant contributions. Microbial biochemistry will undoubtedly be more and more oriented toward the study of growth processes, and research in this direction is being encouraged at the Pasteur Institute.

Such research must naturally be pursued at several levels of chemical complexity. The study of the biosynthesis of large biological molecules poses special problems, but it demands parallel studies

of the biosynthesis of the constituents of the large molecules, namely, amino acids and puric and pyrimidic bases. Moreover, in the living cell these different biosynthetic pathways are organized and integrated with respect to one another. Problems of pure biochemistry, such as the study of individual enzyme reactions, must be considered in relation to the physiological problems of the regulation and organization of the syntheses during growth. The physiology and the chemistry of biosynthetic reactions must, therefore, be studied in parallel, through close collaboration of chemists, physiologists, and enzymologists.

At this point, another essential aspect of modern microbiology must be considered. Microbiology has invaded not only biochemistry but also genetics, and the progress of microbial genetics during the last 10 years has indeed been spectacular. One of the most remarkable developments has been the discovery of a new methodology for the analysis of biosynthetic pathways. The contribution of genetics to biochemistry through the common link of microbiology has therefore been extremely important. Microbial biochemical genetics has helped to solve or advance the solution of many biochemical problems, and it is clear that it will also profoundly affect the development of genetics. In this connection the essential question is of course the mode of action of genes. The most general hypothesis that can be formulated is that genes control the biosynthesis and structure of high-molecular weight cellular constituents, essentially proteins, and ribonucleoproteins. Research on the relationships between genetic factors and the structure of proteins must therefore be encouraged as well as studies on the chemical and physiological factors that specifically control the synthesis of proteins and nucleoproteins. The work done during the last few years at the Pasteur Institute on the multiplication of bacteriophage and on the adaptive biosynthesis of enzymes will be continued within this general framework.

I hardly need to emphasize my certainty that it is by deliberately encouraging research in the more fundamental aspects of microbiology that the most important and substantial results may be expected in the applications of this science, which is of such tremendous importance for the welfare of humanity, and to which the whole activity of our institute has been and will continue to be devoted.

Place of Science in Society Today

HANS VON EULER-CHELPIN

Dr. Von Euler-Chelpin is well known for his many contributions in the fields of biochemistry and the chemistry of fermentation and, in 1929, shared the Nobel prize in chemistry with A. Harden of England. He has been teaching at the University of Stockholm since 1898 and is now director of the Vitamin Institutet, Stockholm.

WHAT sort of relations exist between science and society under the extraordinary conditions and contrasts of the present period and how these relations can alter present ideologies or contribute to new orientations are doubtless questions of international interest. And the consequences of these new orientations may seem to be of even greater importance.

This subject could be treated from different points of view. One could criticize the present place of science in society, or one could try to predict the role of science in future societies under democratic or totalitarian regimes. I prefer to express myself concerning the present period and offer some hope for the future, omitting—since I am an optimist—the fears.

In every country there exist *special* relations to science, based on racial and historical influences, on which the place of science depends. The role of science is, for example, different among the Anglo-Saxon and Scandinavian peoples from that among the Latin peoples, whose feeling for and interest in the arts predominates. But every culturally advanced society must grant to science a position in which full freedom of research and teaching is secured and in which a sound development is possible.

The degree to which a sympathetic attitude toward science exists in a nation or community reflects the sacrifices that have been made for scientific progress. In many periods of history we find examples of a society and its leaders attracted

A group of scientists at a luncheon at Squibb Park. Left to right: René J. Dubos, Frank L. Horsfall, and Richard E. Shope, all of Rockefeller Institute for Medical Research; and William A. Feirer, executive vice president of E. R. Squibb & Sons.

by a measure of idealism toward scientific progress. In this country, an outstanding example of such idealism is the activity of the Rockefeller Foundation, which gives altruistic support to the advance of science in all parts of the world. The necessity of maintaining scientific research as the base for technical efficiency seems to be understood today even in countries where scientific freedom is restricted and where freedom of thought is not recognized as a fundamental principle.

In democratic countries, scientific research is more or less adequately—in America, sometimes generously—supported, and society is apparently conscious of the immeasurable debt it owes to the men who have freed humanity from frightful epidemic diseases and who devote their lives to the betterment of human welfare.

How much science influences different strata of society and the intellectual and moral life of these strata depends on many circumstances. It is natural that science should touch the hearts and minds of men more deeply when they realize the benefit their country derives from scientific progress. In this connection, I might mention the interest of the intellectually indifferent classes in the results of medical research—for example, cancer—or their interest in experiments on atomic energy.

The pursuit of science for its own sake has sometimes led to great and unexpected discoveries, and the successful pioneer then finds society interested and helpful. On the other hand, a scientist working without contact with practical life misses the impulse that the approach to a practical problem gives.

If we wish science to serve as a dominant factor in the intellectual life of people throughout the civilized world, we must first endeavor to procure for scientific principles a central place in *education*. I do not wish to discuss here details of elementary instruction or school curriculums, but I do wish to emphasize how important it is, to the

mental and moral recovery of the world, that the coming generation learn early the strict objectivity that science demands in all our judgments, so that they can avoid prejudices and resist the dangerous influences of propaganda. Today, as in centuries past, young people read history in their schoolbooks as a summary of political conflicts and military victories in which the heroes—and how many energetic and intelligent boys dream of becoming heroes?—are the victorious generals. Seldom have heroes of cultural victories been given the prominent place they merit in schoolbooks. Young people generally do not learn the important influence of cultural progress on society and are, therefore, not stimulated to embark on a scientific career or to challenge the great cultural problems that beset our world.

Still more important is it for society that the spirit of science penetrate the minds of governing bodies of academic and other organizations. It is, of course, very difficult to find men who combine wide knowledge with the administrative ability required to lead large academic organizations. Such men not only are responsible for the successful continuation and expansion of the scientific activities within their organization but also must have the imagination to recognize the coming scientific leaders and to see the importance of giving new branches of science a chance for development. I am referring not only to universities and to the special interest of scientific research but also to the decisive influence that science has or does not have in government, the center of political power.

It is of immeasurable benefit if the spirit of scientific objectivity, the spirit of tolerance, and the faculty of understanding are represented in government. Such a spirit is a guarantee of peace. *"Tout comprend c'est tout pardonner."* The first requirement in this connection, in political as well as in academic life, is the possession of keen intelligence by our leaders.

In my youth I had the great privilege of studying under Jacobus Henricus van't Hoff. He was not only one of the greatest chemists of the last century but also the most imposing personality I have ever met. On one occasion, when I had severely criticized a member of a chemical commission in Berlin, van't Hoff, who had a fine sense of humor, interrupted me in his peculiar Dutch-German dialect:

> Euler, *sei Sie nicht so streng.* Should we not be grateful for honest but slightly short-sighted men; have you never thought of how laborious life would be if we always had to contend with geniuses?

But then he looked serious and continued:

> Of course, when mediocrity tries to gain a dominant influence in leading positions, we must defend with all of our energy the domination of men representing common sense and open-mindness to new ideas.

The spirit of science in the minds of our political and cultural leaders is the one hope for the present and for progress in the future.

For the future, I have one more desire: adult education for the part of society that is least open to intellectual and cultural influences and is therefore most threatened by destructive propaganda.

In the beginning of this century, chemotherapeutic research produced results that only a few years earlier, would have been regarded as impossible. Personally, I am convinced that coming studies in the field of *social psychology* will enable us to understand the nature of mental diseases and of many nervous disorders. If I were 60 years younger I should not hesitate to devote myself to the study of social psychology or psychiatry.

My desire that science take a dominant place springs from no egoistic motives on behalf of scientific research. The penetration of the sciences into all strata of society and among all nations and races offers hope for future progress and more *stable and rational* social conditions.

A Chemical Christmas Tree

Our cover this month is a photograph of a silver tree grown in the laboratory of the Department of Chemistry, University of Texas, for classroom demonstration purposes. The tree resulted from the immersion of a copper sheet in a silver nitrate solution. The spectacular growth of silver crystals occurred within an hour. The jar that contains it is 7 in. high and 6 in. in diameter. The experiment has been described in detail by W. H. R. Shaw and B. T. Nowlin in *Journal of Chemical Education* **30**, 581 (1953).

Photosynthetic Reclamation of Organic Wastes

HAROLD B. GOTAAS, WILLIAM J. OSWALD,
HARVEY F. LUDWIG

Dr. Gotaas is professor of sanitary engineering and director of the Sanitary Engineering Research Laboratory of the University of California at Berkeley. He received his training at the University of South Dakota, Iowa State College, and Harvard University. During World War II, he served in a military capacity in Latin America with the Institute of Inter-American Affairs as chief engineer, director of health and sanitation, executive vice president, and finally president of the institute. Mr. Oswald is assistant research engineer and engineer in charge of the Algal Project of the Sanitary Engineering Research Laboratory, University of California, Richmond. After 5 years in the Army Medical Corps, he took degrees in civil and sanitary engineering at the University of California and has been continuously engaged in algal research since 1950. Mr. Ludwig is sanitary engineer director in the U. S. Public Health Service and is currently assigned as engineer consultant in the Office of Health Emergency Planning, Office of the Surgeon General. He previously taught at the University of California, where he was engaged in the research project on treatment of sewage through algal-bacterial symbiosis in 1950–51.

THE advent of water carriage as a method for transporting sewage permitted the easy removal of such organic wastes from man's immediate environment. As cities and industries have expanded, however, it has become increasingly difficult to carry out the ultimate disposal of this organic matter as necessary to protect the public health, maintain the quality of natural waters, and prevent nuisances.

Engineers have continually improved the efficiency of known methods of waste disposal and have given considerable attention to the development of more economical processes. Primary sedimentation followed by biological treatment involving aeration on a trickling filter or in an activated sludge tank, and by anaerobic digestion of the unoxidized organic solids, have in most instances provided effluents satisfactory for discharge into water courses. For economic reasons, common treatment methods have not been designed to recover any appreciable quantity of the approximately 5 million tons annually of organic and other nutrients contained in American domestic sewage. Sewage treatment, therefore, represents a loss of the energy and fertility values in sewage, besides involving the expenditure of considerable sums of money for treatment plant operation.

Conventional secondary sewage treatment on trickling filters or by the activated sludge process depends upon mechanical means to supply the oxygen necessary for bacteriological removal and stabilization of the organic material. For more than 25 years engineers have attempted to reduce the cost of providing this oxygen by using sewage oxidation ponds. These have customarily been designed to detain the sewage long enough to allow sufficient oxygen for stabilization of the organic matter to enter by slow diffiusion from the atmosphere.

Algae are frequently observed near the outlet of oxidation ponds where the sewage is usually well oxidized, but there has been little information on their growth in such an environment, and until recently there was considerable difference of opinion on whether algae would grow in relatively strong sewage or polluted waters in sufficient numbers to provide significant amounts of oxygen.

The possibility that algae might supply oxygen to sewage less expensively or more efficiently than mechanical devices or diffusion can supply it from the atmosphere led the Sanitary Engineering Research Laboratory of the University of California to initiate studies designed to determine whether algae could be effectively grown in sewage and other organic wastes and to explore the basic factors influencing algal growths on such mediums. Some of these studies, previously reported by us (*1–4*), have shown that when proper environmental conditions are maintained, certain green algae will grow in large numbers simultaneously with bacteria in

fresh organic wastes or sewage. When such growth is taking place, biological oxidation and photosynthetic reduction proceed rapidly, each process aiding the other.

This report (*5*) deals primarily with pilot-plant experiments, designed to show whether, under practical outdoor conditions, algae can be grown in sewage simultaneously with bacteria, not only for purifying sewage, but also for harvesting the algae to reclaim a part of the enormous quantity of materials now being wasted. Laboratory-scale studies are included only to introduce some of the results obtained from the less rigidly controlled pilot-plant experiments.

Photosynthetic Oxygenation. The simultaneous growth of bacteria and algae in organic wastes such as sewage is illustrated in Fig. 1. The liquid wastes containing considerable amounts of organic matter, phosphorus, magnesium, and micronutrients are detained in a growth tank an optimum length of time for the organic material to be broken down by bacteria and the nutrients thus released assimilated into algal cell material. The bacteria normally present in sewage in large numbers (up to 1×10^6/ml or more) decompose some of the organic matter, releasing carbon dioxide, ammonia, and other algal growth essentials, before the sewage reaches the tank. This influent sewage is then seeded with algae by recirculating some of the tank effluent. In the presence of light, these algae flourish, producing the oxygen needed by aerobic bacteria, which, in continuing to stabilize the organic matter, make more carbon dioxide and ammonia available to the algae.

The relative amounts of materials utilized in different aspects of the process are suggested by the width of arrows in Fig. 1. Thus, it is seen that most of the organic matter undergoes bacterial decomposition, an unknown amount of the influent material is utilized directly in algal synthesis, and some inorganic compounds and humus pass unutilized into the effluent. The algal cell material produced may exceed the original organic content of the sewage. Some oxygen escapes to the atmosphere and some carbon dioxide enters the liquid from the atmosphere, particularly when the algae have produced a high *p*H in the liquid. Relatively large amounts of stable organic matter (that is, highly oxidized) and inorganic compounds are present in the effluent liquid.

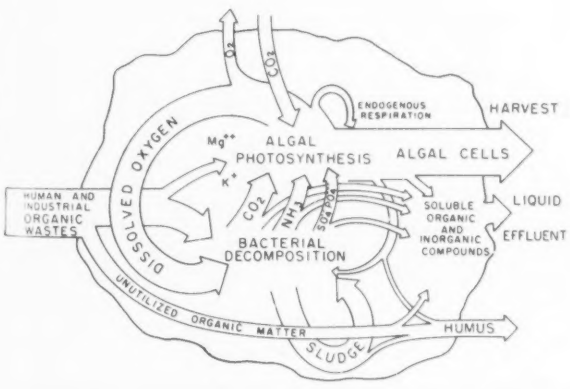


Fig. 1. Schematic diagram of the interaction of bacteria and algae in organic wastes.

For illustration, the basic reactions included in bacterial oxidation and photosynthetic reduction may be shown in the form:

$$\text{Organic matter and other nutrients in sewage} + \text{oxygen} \xrightarrow{\text{bacteria}} CO_2 + NH_3 + H_2O$$

$$\text{Green plants} + \text{light}$$

or represented by the reversible reaction:

$$CO_2 + H_2O \underset{\text{bacteria}}{\overset{\text{algae} + \text{light}}{\rightleftharpoons}} CH_2O + O_2.$$

These reactions take place simultaneously and represent the basic concept of the process. The reaction

$$CH_2O + O_2 \xrightarrow{\text{bacteria}} CO_2 + H_2O$$

represents in part the action of bacteria upon the dead organic matter (CH_2O) in the sewage. Assuming an adequate and diverse bacterial flora, the amount of substrate oxidation depends on the concentration of substrate and the availability of oxygen. Since oxygen from the atmosphere is very limited because of its low solubility, oxygen must be produced by the algae at a high enough rate and in sufficient amounts to permit rapid oxidation by bacteria of the organic material in the sewage substrate.

In the simplified photosynthetic equation

$$CO_2 + H_2O \xrightarrow{\text{algae} + \text{light}} (CH_2O) + O_2,$$

the opposite of bacterial oxidation, the CH_2O represents living algal cells. The algae liberate oxygen to act as the hydrogen acceptor for continued bacterial oxidation. The action of light upon the chloroplastic tissue of the algal cells drives this reaction. The rate is determined by the growth of algal cells, which will depend principally upon the availability of CO_2 and the amount of light. Carbon dioxide is frequently the limiting factor in sewage, and algae

may then obtain carbon by reducing the alkalinity, thus producing a substrate of high *p*H.

The requirements of the process for cultivating algae in waste organic liquids differ considerably from those for growing algae in an inorganic substrate to which carbon dioxide is fed (*6, 7*). Some of the major differences are as follows. (i) The food concentration and volume of substrate can be controlled when inorganic chemicals are used but will be variable for sewage. (ii) The liquid effluent from inorganic substrates can be reused in the process. In the case of sewage, however, large volumes must be handled and the liquid effluent must be continuously and satisfactorily discharged into a natural water course without creating a nuisance or public health problem. (iii) Sterile cultures are preferred in the inorganic process, whereas bacteria present in large numbers in the sewage substrate are necessary for growing algae on sewage. (iv) A greater degree of algal species control can be exercised when an inorganic chemical substrate is used than when a sewage substrate is used. (v) The bacteria actively decompose organic matter either in light or darkness; hence, the algae must supply enough oxygen to maintain aerobic conditions during the period of darkness. (vi) The operating time for harvesting algae can be controlled in the inorganic chemicals processes, but removal of algae must be practically continuous when sewage is used as a substrate. (vii) There may be plant growth nutrients in sewage that would be difficult and costly to supply to the inorganic substrate.

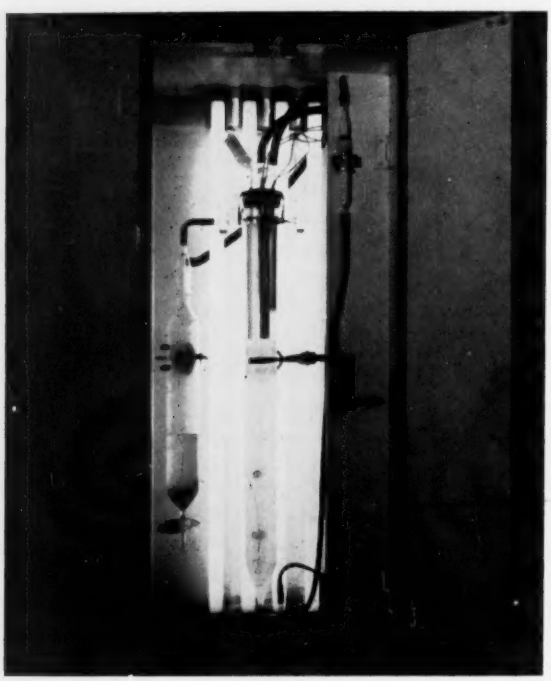


Fig. 2. Automatic continuous-growth unit used in laboratory experiments.

Laboratory experiments. Laboratory studies pertaining to growth characteristics of pure cultures of *Euglena gracilis, Chlorella pyrenoidosa, Scenedesmus obliquus, Chlamydomonas algloeformis* in a substrate of sewage that had been sterilized and inoculated with sewage bacteria were conducted in 1-lit continuous-growth units with fluorescent lighting similar to the units shown in Fig. 2 (*8*). The same organisms were grown in sewage, milk wastes, animal manures, and cannery wastes in nonsterile 50-ml batch cultures. *Euglena gracilis* has been the species studied most extensively, because it has a slower regeneration rate and, hence, smaller amounts of sterilized constant strength sewage, which is difficult to prepare and maintain, are required. Five factors—substrate strength (organic materials and other nutrients); detention period; light (intensity, periodicity, and intermittency); gas exchange in closed units; and temperature—have been investigated for *E. gracilis.* Individual tests have been made with other organisms in order to check or correlate their growth with *E. gracilis.*

Pilot-plant experiments. To translate the laboratory data obtained with fluorescent lighting and sterilized wastes inoculated with sewage bacteria to plant operation with natural lighting and normal variable quality sewage, a continuous-flow pilot-plant growth tank was used. This tank is 80 ft long, 3 ft (average) wide, and 3.5 ft deep. The 3.5-ft depth was selected because it has been the usual practice to build oxidation ponds at least 3 ft deep. This tank is shown in Fig. 3, along with a wider and shallower tank that has more recently been put into service. Both tanks are equipped with automatic devices to control rate of sewage inflow, liquid depth, and rate of recirculation of effluent to seed the incoming sewage. The effluent may be pumped to a centrifuge for harvesting the algal cells on an experimental scale. Normal outdoor lighting is used. Under this condition the only factors that are controllable are the detention period, depth of sewage in the tanks, which affects the light available to the algae, and the rate of recirculation of effluent for seeding.

The detention period, or time the liquid is held in the continuous-flow growth tanks, may be defined as $D = \frac{V}{v}$, where D is the detention period expressed in days, V is the volume of the culture, and

Fig. 3. Continuous-flow growth tanks used in pilot-plant experiments.

v is the daily feed or withdrawal volume. Four different detention periods were studied for each of three different depths—2, 6, and 12 in.—as is shown in the operational schedule, Table 1.

The tanks are oriented in a north and south direction; hence, the time that the water surface at shallow depths receives direct sunlight each day is approximately the same in all seasons, although the light intensity increases and decreases from the solstices. The experiments with a 2-in. depth in the pond were begun on 10 June 1953 and extended until 27 July. Hence, they were made in the period of maximum annual light intensity. This study was followed consecutively by other studies of equal duration at the 6-in. and 12-in. depths, which continued until 19 October 1953. Thus, in judging the results, it is necessary to bear in mind that the experiments at the two greatest depths were made in a period of decreasing light intensity.

The total daily visible light was determined by a pyroheliometer which continuously records the total solar energy as British thermal units per square foot. One-half of the area under the recorded curve provides the approximate total visible light energy per day. Light intensity was also measured daily with a Weston light meter calibrated in standard foot-candles. Since, when the sun was shining, the 3.5-ft high sides of the tank shaded the substrate surface in the early morning and late afternoon, it was necessary to determine by tests how much light energy was received by the cultures. It was found that approximately 0.6 of the total daily visible light determined from the pyroheliometer was available to the substrate surface.

Ambient temperatures were recorded continuously, and temperatures of the liquid were observed twice daily.

Chemical determinations. The chemical character of the influent sewage, of the algae, and of the effluent after the removal of the algal cells, was determined. "Biochemical Oxygen Demand" (BOD) (*9*) was used as an index of the organic-matter content of the sewage because it is a widely used mass bioassay method for determining the strength of sewage or its organic nutritional character for bacterial growth (*10*). Values were reported for 5-day incubation at 25° C. The volatile solids determination was used to ascertain the total amount of organic matter.

Spectrographic and standard methods were used for the determination of organic and inorganic ni-

Table 1. Operational schedule for pilot-plant experiments.

Date started	Series	Run	Pond depth (in.)	Pond volume (gal)	Nominal detention period (days)	Daily influent or effluent volume (gal)	Recirculation rate (gal/hr)
6/10	I	1	2	251	2.5	101	10
6/23	I	2	2	251	0.75	335	24.5
7/3	I	3	2	251	1.25	200	16.6
7/14	I	4	2	251	5.0	50	4.2
7/28	II	1	6	756	5	151	12.6
8/7	II	2	6	756	3	252	21
8/20	II	3	6	756	2	378	32.3
8/28	II	4	6	756	1	756	63
9/9	III	1	12	1566	7	224	18.6
9/19	III	2	12	1566	5	313	26.0
9/30	III	3	12	1566	3	522	43.6
10/12*	III	4	12	1566	1.5	1044	88.0

* Completed 19 Oct. 1953.

trogen, phosphorus, sulfur, calcium, magnesium, potassium, sodium, iron, manganese, boron, zinc, alkalinity, and *p*H. Carbon and hydrogen in the sewage and algal cells were measured by a standard carbon and hydrogen train apparatus. The chlorophyll content of the algae was determined by the method of Mackinney (*11*).

Nutrient quality of sewage. Very little data are available concerning the exact organic composition of sewage. Considerable data on the elementary analysis of sewage have been accumulated in these studies, but they provide little information on the actual organic compounds present. Sewage contains a wide variety of organic materials, together with considerable quantities of calcium, magnesium, sodium, potassium, phosphorus, and traces of most of the elements found in foods. Table 2 shows an elementary analysis of sewage compared with standard inorganic culture medium. It is seen that chemical quality of the two substrates differ considerably.

Figure 4 shows the yield of *E. gracilis* with batch and continuous cultures in sewage of different 5-day, 25°C BOD values. The batch culture shows that with a 7-day detention period the yield of algae

Table 2. Comparative composition of a settled sewage and a synthetic medium for algal growth.

Element	Composition of medium in ppm of indicated element	
	Standard pilot plant*	Settled Richmond sewage†
C	‡	176§
N	346‖	50#
P	248	11
S	335	19
K	1330	14
Mg	248	22
Na	5.5	62
Ca	15.0	17
Fe	0.15	<1.0
B	.5	<0.5
Mn	.5	.2
Zn	.05	Trace
Cu	.02	<0.05
Mo	.01	Trace
BOD		212

* From "Pilot Plant Studies in the Production of *Chlorella*" (*7*).

† Mean values from 10 or more analyses. The coefficient of variation is less than 20 percent when samples are collected at approximately the same time each day.

‡ Carbon supplied from 5 percent CO_2 in air.

§ Including organic carbon and carbon contained in alkalinity.

‖ Nitrate nitrogen.

Including 13 ppm organic N, 37 ppm ammonia N, and traces of nitrate N.

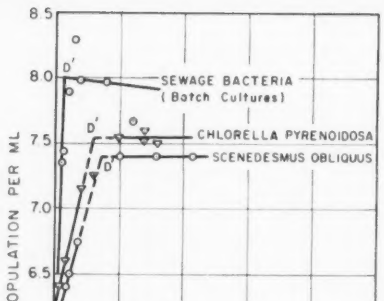


Fig. 4. Effect of detention period on equilibrium populations of sewage bacteria and various species of algae.

increased directly with BOD up to a value of about 300 ppm. Thereafter a slight decrease occurred. The continuous culture shows a higher yield than the batch culture without any evidence of reaching a maximum. These and other data for algal growth on milk wastes, animal manure, and abattoir wastes indicate that the yield of algae is about proportional to the strength of the waste if other nutrients are not limiting. Carbon has usually been found to be the limiting element. It is possible that at times phosphorus might become limiting, particularly at long detention periods when considerable phosphorus may become bound up in bacterial and algal cells. When the vigorously growing algae have raised the *p*H to 10, some of the phosphorus may be precipitated, hence limiting that available to the algae.

Comparative yields for *C. pyrenoidosa* and *S. obliquus* in the same substrates for similar conditions have invariably been larger than for *E. gracilis*.

Table 3 shows the comparative composition of fresh-water and sewage-grown algae. The mean values for the quantities of different elements in sewage-grown algae are similar to those of fresh-water algae, except that the percentage of carbon in the sewage-grown algae is below the range for fresh-water algae. This may be due to the fact that carbon is usually a limiting element in sewage.

If the usual method of multiplying the nitrogen content by 6.25 to estimate the protein is applied, it is seen that algae grown in sewage average 55 percent protein.

Detention period. The effect of varying the de-

tention period (D) on the cell population of different species of algae under laboratory conditions is shown in Fig. 4. The critical detention period (D') at which the maximum equilibrium population occurs differs with the species, being shortest for the smallest organisms studied. In previous reports (*2, 4*), it was shown that for the condition D greater than D' the algal cells are old, grow slowly, and hence produce little more or even less oxygen than they use in respiration. When D is less than D' algal growth is in the logarithmic phase, and oxygen is produced in excess of the needs of all organisms in the system.

The detention period (D') for maximum population does not coincide with the detention period (D'') for maximum yield of photosynthate. Figure 5, based on previous laboratory studies of *E. gracilis* and *C. pyrenoidosa,* shows that D'' is less than D' for maximum yield of dry cell material. For periods shorter than D'' the yield decreases rapidly because the cells do not multiply as fast as they are removed from the system. A minimum detention period at which an equilibrium reproduction rate can be maintained is thus imposed by the regeneration time of the species, and a practical lower limit is set on the economy of growing algae in growth tanks on a continuous basis.

Since bacteria multiply more rapidly than algae, their regeneration time does not limit the detention period. The BOD that they exert during the detention period, however, must be satisfied by oxygen

Table 3. Comparative composition of fresh-water and sewage-grown algae.

Element	Percentage of total dry weight in	
	Fresh-water algae	Sewage-grown algae
Carbon	49.51–70.17*	44.9†
Oxygen	17.40–33.20*	25.7†
Hydrogen	6.57–10.20*	7.69†
Nitrogen	1.39–10.98*	8.92†
Sulfur	0.91‡	1.11§
Phosphorus	0.94– 1.51‖	1.00§
Calcium	0.00– 1.55‖	1.2#
Magnesium	0.26– 1.51‖	0.35#
Manganese		.001#

* Spoehr and Milner as reported by Kraus (*12*).

† Mean values based on 10 or more analyses of algae in pilot plant; coefficient of variation less than 10 percent.

‡ Kraus (*12*).

§ Mean values based on 10 or more analyses of algae in pilot plant; coefficient of variation approximately 60 percent.

‖ Scott as reported by Kraus (*12*).

Mean of five analyses from laboratory cultures of *E. gracilis*.

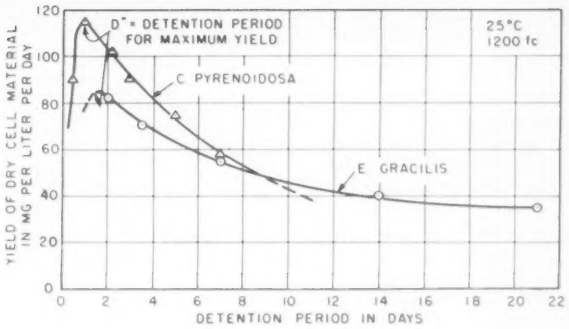


Fig. 5. Laboratory yields of algal cell material grown in sewage at various detention periods.

made available by the algae. If a high degree of sewage treatment is to be accomplished, excess oxygen is required and the detention period should approach D', even though a greater yield of algae might be obtained at D''.

In the outdoor pilot-plant studies the relation of detention period to cell population of different species was not determined because artificial control of species is impossible. A growth tank inoculated with 20 gal of *E. gracilis* culture was rapidly overgrown by *Chlamydomonas,* which in turn soon gave way to *Chlorella* and *Scenedesmus.* These latter two organisms were numerically dominant in the experiments summarized in Table 4. These data show the *Chlorella* population increasing with detention period and decreasing with tank depth, while the *Scenedesmus* population increased with both detention and depth. *Chlamydomonas* and *Euglena* were endemic in the culture but were unable to compete with the more rapidly growing species. At longer detention periods such as 7 days at the 12-in. depth (Table 4) *Euglena* increased until the mass of its cell material was as great as that of other species in spite of its numerically small population.

Figure 6 shows the relationship between detention period and average daily yield of algae at different tank depths. The dispersion of the curves may be exaggerated somewhat because sludge settled to the bottom of the tank at the 6- and 12-in. depths, leaving the algae in an impoverished liquid medium, whereas at the 2-in. depth there was little opportunity for food stratification or anaerobic bacterial decomposition of the settled sludge, since it remained in the light and, hence, was subject to photosynthetic oxygenation.

The variation in chlorophyll content of the cell material with detention period for various tank depths is shown in Fig. 7. At the 2- and 6-in. depths the chlorophyll content increased to a maximum,

Table 4. Algal counts, total and by genera at various depths and detention periods.

Depth (in.)	Detention period (days)	Total count (cells/ml × 10^{-6})	Algal population by species (cells/ml × 10^{-6})			
			Chlorella sp.	*Scenedesmus* sp.	*Chlamydomonas* sp.	*Euglena* sp.
2	0.75	4.06	3.54	0.40	0.12	
	1.25	3.00	1.68	1.11	.21	
	2.50	15.10	14.60	.46	.10	0.01
	5.00	4.99	3.80	.96	.14	.04
6	0.92	1.56	0.52	1.04		
	2.10	2.62	1.34	1.28		
	3.10	4.80	0.90	3.90		
	5.15	8.62	3.80	4.62	.20	
12	1.50	1.72	0.98	0.49	.20	.01
	3.00	1.82	1.08	.72	.02	
	4.90	3.64	1.60	1.92	.06	.06
	7.18	3.58	1.32	1.66	.30	.30

then dropped off, probably owing to a combination of photo-destruction of chlorophyll and decrease in nutrients as detention period increased beyond a critical point. This is consistent with the results of laboratory experiments (*3*) using pure cultures of *C. pyrenoidosa* at constant light intensity. The continued increase, instead of a decrease, of chlorophyll at the 12-in. depth as the detention period increased was probably due in part to light limitations. Inasmuch as the 12-in. study was the last of the series it was made in September and October, when the amount of light is diminished. It is difficult to correlate the yield shown in Fig. 6 for the 12-in. depth and 1.5-day detention with the small amount of chlorophyll contained by the cells grown under these same conditions, as is shown in Fig. 7. There is evidence, however, that at detention periods less than 2 days bacterial cell material may contribute an appreciable part of the apparent yield of algal cell material.

Observations to determine the effect of detention period on BOD removal were made both in the laboratory and in the growth tanks. In the laboratory BOD removal was not significantly affected by detention period except at very high BOD loadings corresponding to extremely short detention periods. Under these conditions photosynthetic oxygenation is limited. Pilot-plant results shown in Fig. 8 indicate, however, that at the greater depths there may be an optimum detention period for maximum BOD removal. Maximum removal at the 2-in. depth occurred at the shortest detention period studied, but for greater depths larger detention periods were required, probably because light became limiting.

Light, depth, and energy conversion. Laboratory studies have been previously reported (*4*) on the effect of varying light intensity in growing *E. gracilis* at 25°C under a 7-day detention period in a sewage that had been sterilized and inoculated with sewage bacteria. The findings included the observation that maximum algal population and maximum dry weight yield of cells occurred at light intensities between 400 and 1200 ft-ca. Chlorophyll per cell was greatest for light intensities less than 400 ft-ca and decreased rapidly to low amounts at intensities above 800 ft-ca. Since cultures were developed under unilateral illumination, and *E. gracilis* has an elongated shape such that when it is pointed toward or away from the light source only a small portion of the cell receives light, these values would seem to be consistent with the values near 400 ft-ca suggested by Myers (*13, 14*) as representing the saturation intensity for single *Chlorella* cells—that is—the intensity above which no further benefit is evident.

The apparent photosynthetic efficiency in pilot-plant investigations was calculated by dividing the light energy incident to a unit volume of culture, as measured by the pyroheliometer, by the energy bound up in the algal cells grown per unit volume. Shading of the substrate surface by the high side walls of the tank excluded about 40 percent of the total daily light energy. The available portion of the remainder averaged 103, 82, and 58 cal/cm^2 per day for the 2-, 6-, and 12-in. depths, respectively. The energy content of the algal cells was determined by standard calorimetric methods.

Figure 9 shows the average apparent photosynthetic efficiency in relation to detention period for different depths. Each of the plotted points represents from 4 to 7 determinations of the dry weight of algae. It is possible that the high apparent photosynthetic efficiency at the shortest detention periods may be deceptive because of direct assimilation of

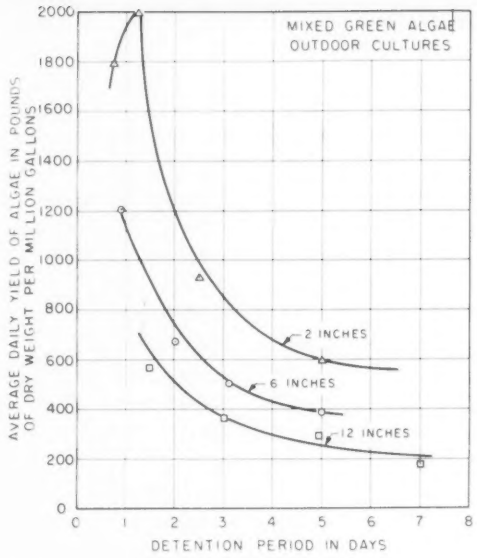

MIXED GREEN ALGAE
OUTDOOR CULTURES
AVERAGE DAILY YIELD OF ALGAE IN POUNDS OF DRY WEIGHT PER MILLION GALLONS
2 INCHES
6 INCHES
12 INCHES
DETENTION PERIOD IN DAYS

Fig. 6. Average daily pilot-plant yields of algae as affected by detention period and depth.

organic nutrients from the sewage by the algae as well as by the bacteria. A replot of the data of Fig. 9 in relation to depth is shown in Fig. 10, which illustrates that the efficiency of solar-energy utilization increases with depth.

The yields of algae shown in Fig. 6 for 2-, 6-, and 12-in. depths and different detention periods are converted to energy yields and shown in Fig. 11 for detention periods of 2, 3, 4, and 5 days. The energy yield in the form of algae per cubic foot of sewage is greatest for the shortest detention period and the shallowest depth. The algal cell energy yield decreases rapidly with both increasing depth and detention. Comparing Figs. 10 and 11, it is seen that maximum photosynthetic efficiency occurs at greatest depth, and maximum energy yield occurs

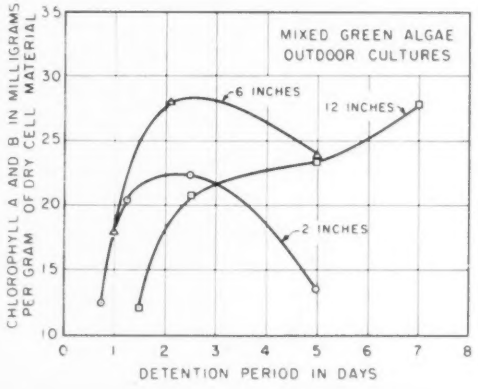


Fig. 7. Effect of depth and detention period on algal chlorophyll content.

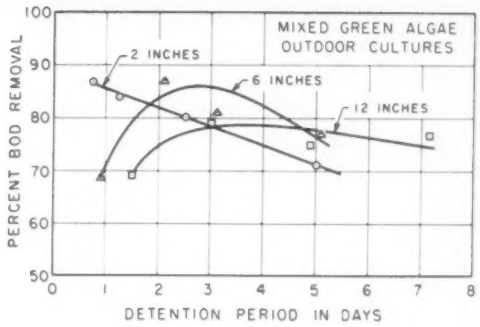


Fig. 8. Effect of depth and detention period on BOD removal.

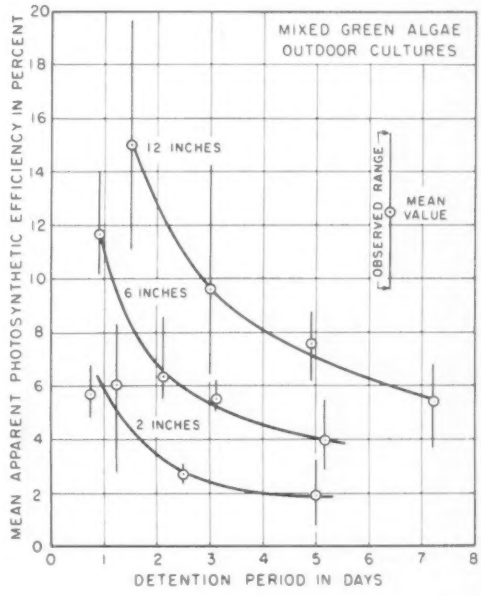


Fig. 9. Mean apparent photosynthetic efficiency at various detention periods for constant depths.

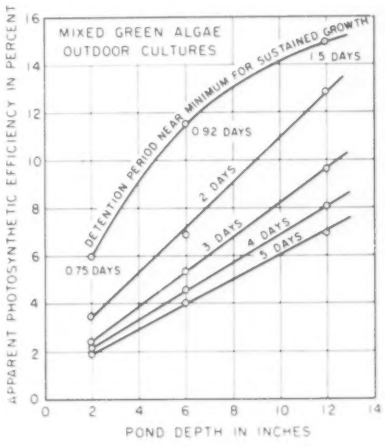


Fig. 10. Apparent photosynthetic efficiency at various depths for constant detention periods.

at minimum depth. Thus, maximum efficiency in utilization of light is obtained at sacrifice of efficiency in utilization of nutrients, and vice versa. For maximum sewage treatment where the object is efficient utilization of nutrients, therefore, light should not be limiting.

Yield of algae. The algal yields in sewage on an acre basis are quite high compared with normal crop yields of plants on agricultural land. Figure 12 shows the yield in tons per acre per year for 2-, 6-, and 12-in. depths and varying detention periods. For the shortest detention periods at the 6- and 12-in. depths, the respective yields are 35.6 and 33.6 tons/acre per year. The maximum yield at the 2-in. depth is 22.5 tons/acre per year, which is considerably below that for the two greater depths. It is believed that if a detention of about 1 day instead of 0.75 day at the 2-in. depth had been used, the maximum yield might have been considerably higher.

The yield of algae per unit area increases directly with the loading of organic matter per unit area until light becomes limiting. At the 6- and 12-in. depths the rate yields were approximately 15 tons/acre per year for a BOD loading of 100 lb/acre per day, and 35 tons/acre per year for the maximum loading investigated of 420 lb/acre per day. The high yields and loadings were near the upper limit for light and detention time in the experiment, but the degree of sewage treatment accomplished was reduced.

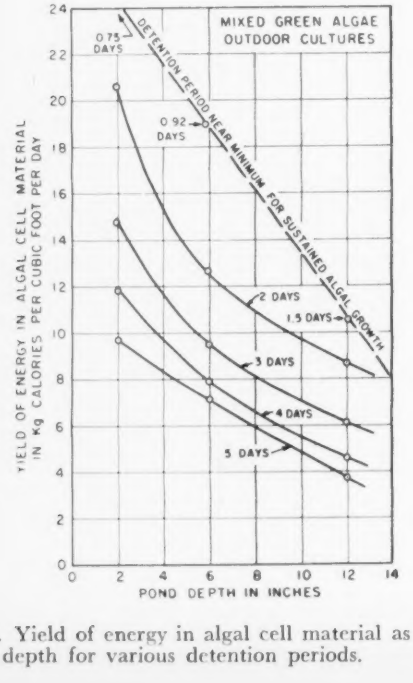


Fig. 11. Yield of energy in algal cell material as a function of depth for various detention periods.

If the yield per acre per year is analyzed in terms of loading in pounds of BOD per acre per day, it will be seen that the yield increases with loading until the light becomes limiting and the algae do not increase sufficiently to provide the oxygen required to keep the culture aerobic.

There is evidence that yields can be improved by keeping the substrate sufficiently turbulent to prevent flocculent particles of organic food material from settling to the bottom of the tank. This would keep the bacteria and nutrients in close contact with the algae and prevent anaerobic decomposition with its release of methane, which is not a source of carbon for algae. Also, greater agitation may improve the light utilization by the algae, as concluded by Kok (*15*) in his studies of light intermittency through turbulence.

Harvesting of algae. In the experimental investigation, centrifuging has been used for harvesting the algae needed for the various studies. Present centrifuge equipment does not appear to be satisfactory from an economic standpoint for separating the algae from the large volumes of liquid used in growing algae in sewage. In laboratory experiments, algae have been readily precipitated with alum as a coagulant, forming an aluminum hydroxide-algal floc. Studies are in progress to determine the feasibility of separating and recovering the aluminum floc. Since the alum dosage required is relatively large, this is desirable both because the mixture would have decreased nutritive value, and because the recovered aluminum could be reused. It is also possible that some flotation process might permit separation of the algae from the water to an extent such that spray drying might be accomplished.

Discussion. The information reported here, together with other laboratory data, shows that algae will grow abundantly in sewage, utilizing nutrients made available by aerobic bacteria which oxidize the organic matter in sewage. Furthermore, this algal growth will supply sufficient oxygen for the bacteria and will produce large yields of cell material high in protein content. It is evident, therefore, that sewage may have important possibilities as a low-cost nutrient for industrialized photosynthesis. Assuming that algal cells can be economically separated from the liquid, the growing of algae in sewage would provide adequate sewage treatment while reclaiming a large part of the organic material contained in such a waste. The process, however, loses much of its value as a method of sewage treatment if the algal cells are not removed. Presumably, effluent containing large numbers of such cells could be emptied into some watercourses

where the rheological environment is such that the cells will continue to live until reaching the ocean, but in general the practice would be impractical. In some rivers, and in lakes or ponds, the load of decomposing organic matter occasioned by the death of algae might place an excessive burden on the oxygen resources of the water. The situation is made particularly acute by the fact that there may be more organic matter in algal cells than was in the original sewage.

The exact amount of algal cell material that can be produced on sewage or other wastes depends upon a number of factors, including the average strength of wastes, amount of light available, the temperature of the waste, and the depth and detention period in the growth units. Present information indicates that growth units designed for from 1.5- to 3-day detention periods, depending on the season of the year, can be operated satisfactorily for the purpose of converting organic and other nutrients into algal cell material. Evidently depths should be quite shallow, probably from 6 to 12 in. in winter in moderate climates, and from 12 to 18 in. or possibly deeper in summer. The most economical detention period and depth would be related to land values as well as to conditions for optimum algal production.

To what extent algae could be grown in sewage during the winter in cold climates is not known, although it seems certain that growth would be small where growth units were subject to freezing. It is known that climatic conditions would permit year-round growing of algae on the Pacific Coast and in the southern half of the United States, and it is believed that algae could be grown in sewage during 6 months of the year in most other sections of the country.

The value of algal cell material is an important item in evaluating the process of treating sewage by growing and harvesting algae. At the present time the degree of sewage treatment necessary to produce an effluent of the quality obtainable by growing and harvesting algae costs from 25 to 60 dollars per million gallons of sewage. It is estimated that algal cell material might be worth approximately 2 dol/ton per percentage unit of protein as a protein supplement for animal feed. At 50 percent protein, this amounts to 100 dol/ton. If, as it now seems possible, from ¾ to 1 ton of algae can be produced per million gallons of sewage under good operating conditions, there would be around 150 dollars per million gallons to pay for treating the sewage and marketing the algal product. It is estimated that growth units could be built for much less than other sewage treatment facilities, the major problem then being the development of an economical method for removing the algae from the liquid.

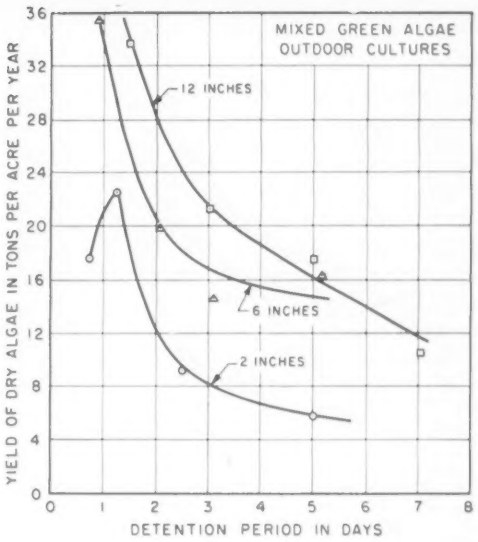


Fig. 12. Yield of algae per acre of land area as a function of detention period for various depths.

Estimates (*16*) indicate that the total annual land photosynthate in the United States has an energy content of about 15×10^{12} kw hr. Of this 2.32×10^{12} kw hr is processed for all purposes, including 1.25×10^{12} kw hr processed for food production. Of that processed for food only 0.13×10^{12} kw hr is actually consumed. About 0.06×10^{12} kw hr is disposed of as domestic sewage, although this quantity is increasing as the growing use of garbage grinders has the effect of transferring greater amounts of food wastes from the refuse can to the sewer. In addition, the amount of organic matter in industrial processing wastes probably approaches that of human wastes. The foregoing values in terms of energy do not represent the total energy content. By utilizing the fertility value of these organic materials as substrate for algal growth, much additional organic matter is created by photosynthesis. Moreover, this organic matter has a greater energy content per unit of weight than had the waste organic materials. Thus, the resultant material has a total fixed energy content much greater than the original waste from which it was produced. One indication of the fertility of the material discharged in American domestic sewage each year is its content of fixed nitrogen and phosphorus. This amounts to some 2.3×10^9 lb of nitrogen worth about a quarter of a billion dollars, and perhaps one-quarter as much phosphorus annually.

In the vicinity of metropolitan areas land suitable for sewage reclamation by algal culture may impose economic limitations on the process. It is possible

that algal growth units could be developed on waste land such as tidal flats or swamp areas. However, since potential yields of algae are from 10 to 20 times those now obtained from cultivated land, it may not be difficult to justify the use of rather expensive land for this process.

Sewage and organic industrial wastes represent a source of valuable raw materials, the quantity of which will increase in parallel with the growth of the earth's population. In a world that is poor in proteins, with untold millions of undernourished people and declining fixed energy sources, it would seem that the reclamation of organic wastes by algal culture has a hopeful future.

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Transition

O, insatiate breast of
Mother Earth,
Giver of life in myriad forms,
Receive with infinite care
This part of him
We knew as father—friend
To all thy children.
This part of him transmute
In your magic crucible,
Returning him to us
In sunset, flower, tree
And cloud.
The rest of him
Will rest with us
Forever undistilled.

CHARLES W. COLLINS

Role of Aircraft in Forest-Pest Control*

EVERT W. JOHNSON

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DURING the years 1939–52 disaster struck the high mountain country of central Colorado. Permitted to build up to unprecedented numbers by favorable conditions and by lack of preventive measures by man, the Engelmann spruce beetle (*Dendroctonus engelmanni* Hopk.) wiped out the Engelmann spruce (*Picea engelmanni* Parry ex Engelm.) in the White River National Forest north of the Colorado River (*1*). In addition, large numbers of spruce were killed in the Grand Mesa, the Routt, the Uncompahgre, the Arapaho, the Gunnison, and the San Juan National Forests. During the course of this attack, more than 4 billion board feet of Engelmann spruce and a half-billion board feet of lodgepole pine (*Pinus contorta* Dougl.) were killed (Figs. 1 and 2). In 1952 the epidemic was finally brought under control by a combination of natural and artificial controls (*2*).

Like all bark beetles, the Engelmann spruce beetle is difficult to control because it spends most of its life under the bark of the host trees. This means that aerial spraying is very inefficient and must be discarded as an effective control measure. Instead, foresters must rely on "sanitation cutting" (the cutting and removal of infested trees from the forest) or on the spraying of insecticides on the bark from the ground. In the Colorado outbreak, owing to the inaccessibility of the spruce, the lack of suitable markets, the wartime lack of manpower, and the lack of funds, little or nothing was done until 1949. Then a program of ground spraying with orthodichlorobenzene and ethylene dibromide was initiated to prevent the spread of the beetle into the remaining spruce stands south of the Colorado River. In 3 years, 1,219,344 trees were treated at a cost of $3,327,946 (*2*). An extremely cold winter and a large increase in the woodpecker population assisted greatly in stopping the epidemic.

Since the fall of 1949, this same insect has been attacking the Engelmann spruce in the Inland Empire region of western Montana and northern Idaho (*3*). Twelve and one-half billion board feet of timber are threatened. In this region, however, the lumber industry is well organized, and control measures were begun relatively early. These control measures took the form of sanitation cutting. Since 3 to 16 percent of the Engelmann spruce in the region is involved in the infestation, control by sanitation cutting is necessarily a large and expensive operation. To meet the requirements of the job, it has been necessary to curtail regular logging operations and to concentrate on the spruce, with the result that by 1953 spruce cutting had increased to 6 times the normal rate. In 1952, 150 mi. of roads were built to provide transportation routes to the infested timber. In 1953 it was estimated that 5 times as much mileage would have to be built. This road-building program was beyond the capacity of the logging industry itself. Consequently, the Congress was asked for an appropriation of $10 million to help pay contractors to fill the gap. This investment is needed to head off a potential loss of more than $500 million in lumber and other forest products, labor, taxes, and other values involved.

The Engelmann spruce beetle is only one of the many pests now attacking our forest resources. The example does, however, illustrate the magnitude of control operations necessary when an insect or disease attacks our forests. Similar attacks are under way at the present time in all portions of the United States. The spruce budworm (*Ca-*

coecia fumiferana Clem.), probably the most destructive of all forest insects at the present time, has caused serious damage to balsam fir (*Abies balsamea* [L.] Mill) and lighter damage to spruce (*Picea* spp.) in the Northeast and Lake States and in adjacent sections of Canada. It is also a major pest in the Pacific Northwest and the Inland Empire where it feeds on both Douglas fir (*Pseudotsuga taxifolia* [Poir.] Britton) and the true firs (*Abies* spp.). Recent reports indicate that it has invaded the Douglas fir forests of the central and southern Rocky Mountains and is causing damage as far south as New Mexico. White pine blister rust, an introduced disease on five-needled pines (caused by *Cronartium ribicola* Fischer), has saddled growers of the white pine (*Pinus strobus* L.; *P. monticola* Dougl.; and *P. lambertiana* Dougl.) in the Northeast, Lake States, Inland Empire, and other white pine-producing regions with a costly burden of disease prevention. The southern pine beetle (*Dendroctonus frontalis* Zimm.) is causing damage in southern pine areas. The little leaf disease of shortleaf pine (probably caused by *Phytophthora cinnamomi* Rand), the oak wilt (probably caused by *Endoconidiophora fagacearum* Bretz), the Dutch elm disease (caused by *Ceratostomella ulmi* [Schwarz] Buisman), and the pole blight of western white pine (whose causal agent is still unknown) are attacking and causing serious damage to some of our most valuable tree species. As one views the fields of forest pathology and forest entomology, it becomes apparent that the protection of forests from damage caused by insects and diseases is a problem of primary importance.

In the beginning of the forestry movement in the United States, the main problem facing foresters was protection. If the forests could not be protected against loss from fire and pests, the financial risks in holding uncut stands of timber were so great that long-range forest planning was impossible. The problem of fire was attacked immediately, probably because fire is spectacular and fire damage is immediately apparent. In contrast, damage caused by forest pests is relatively slow to appear, and usually no sense of urgency develops. In addition it is quite possible that early foresters had little conception of the damage caused by pests. As a result, when we examine the situation after a little more than a half-century of forestry activities, we find that the fire problem, while still large and very important, has been fairly well controlled. A high percentage of our forest lands are under organized fire protection. Attempts are being made through educational programs in the schools to make the next generation more fire conscious, while the forest industries, through the "Keep Green" and other similar adult programs, are trying to bring the problem home to adults. In addition, on the technical side fire-fighting equipment and techniques have been improved to the point where fire losses can be kept at a reasonable level.

Such is not the case with the second major facet of the protection mosaic. Control of forest insects and diseases has progressed much more slowly than control of fire, and it is still very much in the development stage. In epidemic form alone, forest insects and diseases cause more damage than fire (*4, 5*). Losses resulting from endemic populations of pests are difficult to evaluate, but the aggregate loss must be enormous. These losses from insect or disease attack are not always immediately apparent. Trees are often killed, but in addition there are usually less obvious secondary results. The growth of the residual stand may be greatly reduced or the pest-killed timber may be replaced by inferior species. Either or both of these conditions mean revision of the forest-management plan, but much more important is the reduction in the rate of return to capital invested. This fact is of considerable importance, since the land owner may abandon the idea of forestry and invest his money elsewhere if the rate of return dips below that of less hazardous investments. The financial effect of the lack of positive control over forest pests is reflected also in the absence of insurance covering such losses. Forest fire insurance is available in some areas in limited amounts, but pest insurance is nonexistent. The day is coming when losses from forest pests will be a greater deterrent to investment in forest lands than fire.

Problems of Forest-Pest Control

The problems of pest control in the forest are somewhat different from those facing the agriculturist. First, many forest pests, both insects and diseases, are normally useful or innocuous members of the forest community and become dangerous only when conditions favor their development. These pests are normally scavengers that live on dead or dying vegetation and are kept in check by the combination of limited food and attacks by parasites and predators .The afore-mentioned Engelmann spruce beetle is an example of such an insect (*6*). In both the Colorado and the Inland Empire epidemics, extensive areas of blowdown provided a tremendous food supply. As a result, the insect population grew so fast that the para-

sites and predators could not keep it under control. When the food in the blowdown areas was exhausted, the beetle began attacking healthy standing timber. In the case of the Colorado attack, this continued until natural controls and chemical attack brought the beetle population down to normal levels. In the Inland Empire the lodgers are attempting to remove the breeding material as fast as possible and in this way prevent the build-up of a large population.

Second, forest protection differs from agricultural crop protection because of the differences in areas involved. Often an epidemic in the forest can assume serious proportions before it is detected, since the area is not under as close scrutiny as it would be in the case of an agricultural crop. This is particularly true of the North and West where there are large blocks of solid timber with few roads. The South is fortunate in this respect because of its broken forest cover and relatively dense network of roads, except in the mountains and in the coastal swamps.

Third, forest crops have a high aggregate value, but the per-unit value is low. Forest landowners cannot spend much money on protection before they lose their profits. Where timber is a secondary resource, as in the case of a watershed forest, or where the threatened area is large and the infested area is small, expensive intensive control measures can be carried out without excessive financial loss. Such operations, however, cannot be carried out over large areas.

Fourth, intermingled forest ownership complicates the problem. This is particularly true where cooperation among various landowners is not well developed. It is useless to expend large sums of money to eradicate insects or diseases on a tract of land if a neighboring owner does nothing, thus leaving a focus of reinfestation or reinfection. This is one of the major reasons for governmental subsidies and legal procedures for bringing concerted action against serious pests, regardless of who owns the land. A related problem exists in areas of open range, particularly in the South. In such areas the landowner is held legally responsible for any cattle that may be on his land. If an animal becomes sick or dies, the landowner may be sued for the price of the animal if it is assumed that he did something to cause the animal's illness. Control operations involving spraying or tree poisoning in areas of open range are often shelved because of fear of legal action by cattlemen, who might claim that any sick or dead animal had been affected by the control operation. Fortunately the passage of fencing laws is reducing the area involved and is making the control of forest pests easier in the forest-grazing sections of the country.

Fifth, when unknown diseases or insects attack the forest, the forester and his allies, the forest pathologist and forest entomologist, seldom have the monetary resources to solve quickly the problems of identity, life-cycles, and controls that are available to the agriculturist. In addition, the forester has much less control over his crop and land than does the manager of agricultural land. As a result, a great deal of damage can occur between the time of the first attack and the time when effective control measures become available. Sometimes no control measures are developed, and the pest goes on unchecked. Such was the case of the chestnut blight (caused by *Endothia parasitica* Murrill) that eliminated one of our finest hardwoods as a commercial species.

Forest Pest Control Act of 1947. To help meet these problems the Federal Government passed the Forest Pest Control Act of 1947 (*7*). Governmental policy under this act is to "prevent, retard, control, suppress, or eradicate incipient, potential, or emergency outbreaks . . . on, or threatening, all forest lands irrespective of ownership." This shall be done independently or in cooperation with other agencies. The act provides for surveys and for the determination of necessary control measures. It further provides that the Federal Government may carry out such measures, provided that consent is given by other landowners. Under the provisions of this act, considerable work has been done in the North and West, and some has been done in the South. Aircraft have proved invaluable in carrying out the provisions of the act.

Forest-Pest Surveys

Before forest pests can be controlled, it is necessary to know where the epidemic is located, how large it is, and how fast it is spreading (*8*). In order to obtain such information, it is necessary to make periodic systematic surveys of all forest land, regardless of ownership. The traditional method of making such surveys consists of sampling an area in much the same manner as a timber cruiser samples an area for timber volume. In some cases this sampling procedure involves traversing the area on foot on regularly spaced cruise lines. This is the procedure that must be used in inaccessible country with few roads. Where the road network is relatively dense, however, it is sometimes possible to travel along the roads in an automobile and either to record conditions as seen from the road or to make sample checks at regular

Fig. 1. Before the outbreak of Engelmann spruce beetles, the Trappers Lake area of White River National Forest, Colorado, looked like this. Tourists flocked here from all over the country to enjoy one of the West's most scenic attractions. [USDA photo]

intervals measured on the speedometer. The presence or absence of white pine blight (causal agent unknown) was recorded in this manner for each 0.1 mi along the roads in Jackson County, North Carolina. These traditional methods are still in use for evaluating epidemics or infestations of pests that do not affect the upper crowns. The Engelmann spruce beetle is one insect whose presence or absence can be determined only from the ground. Not until about a year after trees are attacked, when they are ready to die, do they change color or appearance. Such ground cruising or checking is expensive, and the amount of area actually covered is relatively small. It is obviously not very effective in evaluating fast-moving or spotty outbreaks.

Visual scouting methods. If early in the attack the pest creates symptoms involving the upper crown, it is possible to take advantage of a downward view to locate the boundaries of the outbreak. This has been done from fire towers. The method is successful only in areas immediately adjacent to the towers. As the distance from the tower increases, the observational error also increases, until beyond a certain point the detection of symptoms becomes unsatisfactory. With this method, as with all the methods involving a downward view onto the forest canopy, ground checking is essential to confirm the results of the survey (*9–11*).

Other procedures utilizing the downward view involve aircraft. The use of aircraft in such an operation can be divided into two broad classes: visual scouting and aerial photographic methods.

Visual scouting consists of flying over the area at low altitudes in a slow-moving aircraft in order to locate infested areas. It is very useful in detecting small, spotty infestations in inaccessible areas before an outbreak becomes too large to control. With aerial scouting methods, it is also possible to follow the development of a fast-moving outbreak with a minimum expenditure of time and money.

Aerial scouting was first used by Craighead in Canada in 1922 and 1923 for determining spruce budworm damage (*8, 12*). Canadian cartographic engineers and foresters were busy at that time attempting to construct base maps of the uninhabited sections of the country by sketching ground detail on the map sheet while flying over the area in two-place biplanes. Craighead apparently borrowed this procedure, and in 7 days he had mapped several thousand square miles that would have taken 3 to 4 months to map by conventional ground methods. The method showed promise, but the techniques in use at that time were useful only in detecting relatively heavy outbreaks.

The use of aircraft in scouting for pests remained more or less a curiosity until World War II. Before the war sporadic attempts were made to use aircraft, but the jobs were small and results were not as good as could be desired. Aircraft was used in bark beetle detection (*8*); but, even though infected trees could be seen from the air, existing maps were so poor that it was very difficult to pinpoint the trees so that ground crews could find them and treat them. The best results were obtained in New England and New York with the Dutch elm disease, which is spread by a beetle. Existing maps of these areas were adequate for the job. Autogiros were used, since they could fly very slowly, permitting accurate plotting of tree positions on the map.

Sketch mapping. Since World War II the use of aircraft has been further investigated and developed. Several procedures are in use at the present time. The first, and probably the most widely used procedure, is sketch mapping. This is a direct descendant of Craighead's technique. There are several modifications of this technique. The first involves sampling the area by flying along predetermined grid lines and plotting damaged areas on base map, aerial photographs, or aerial photomosaics.

This procedure was used to map 700,000 acres in the Pacific Northwest in 1947 at a cost of 0.1 ct/acre (*8*), and is now being used to scout 49

Fig 2. After the beetle outbreak, the same area looked like this. Few of the spruce trees are alive [USDA photo]

million acres annually in the same region for spruce budworm damage. It has also been used in scouting for southern pine beetle in Mississippi and for oak wilt in the northern Mississippi Valley and central Appal[illegible]ns (*13*, *14*). In the latter case, large-scale highway maps are used for planning purposes. The planes are capable of slow, safe flight, usually from 80 to 90 mi/hr. Wing, strut, and window arrangement of the plane must permit easy viewing of the ground. A Cessna 195 with a 300-hp engine and variable pitch propeller was used in much of this work because it has enough power to climb out of trouble and to take off from small fields. Helicopters have been used in Illinois, but rental charges are too high; furthermore, the extremely slow speeds of which helicopters are capable are not needed for this work. The planes are flown at altitudes ranging from 100 to 200 ft above the treetops in order that the understory can be seen. The strips flown are at 50-mi intervals. With one observer, ground is covered at a rate of 17 to 18 mi^2/hr. This rate can be doubled if two observers are used. Infected trees are recognized by a characteristic chrome-yellow or bronze color. The positions of infected trees are noted on the map, and the work is checked from the ground.

Another modification of the sketch-mapping technique has been used to map southern pine beetle infestations in southeastern Texas and in Mississippi (*15*). This involves 100-percent sketch mapping on aerial photographs from an altitude of 2000 to 5000 ft. This is a relatively crude procedure with considerable probable error, but it is a valuable tool for estimates of areas involved in such outbreaks. The total cost in this case was 0.4 ct/acre.

The third, and last, modification of the sketch-mapping technique is detailed mapping on aerial photographs, aerial photomosaics, or maps. This has been used to map outbreaks of the southern pine beetle in Florida and on the Norris Dam watershed of the Tennessee River (*10*). Probably it has been brought to its highest degree of development in mapping areas damaged by the pole blight of western white pine in Idaho (*16–18*). Here again slow powerful planes such as the Cessna 170 or 195 have proved best. The pilots must be skilled in mountain flying, and the planes must be capable of rapid climbing. Flying is done at altitudes of from 250 to 500 ft above the treetops. The area is divided into watersheds, and each watershed is examined individually. First the ridges are flown, and then the slopes are examined as the plane is flown along successively lower contours, dropping about 500 ft downhill at each pass. The flying must be done in the early morning or late afternoon to avoid the turbulence that occurs over the mountain ridges during most of the day. East-facing slopes are flown in the morning and west-facing slopes in the afternoon to make the best use of the light. Three classes of damage can be recognized by changes in foliage color, sparseness of foliage, and shortening of terminal leaders. Suspected stands are examined at 150 to 200 ft for confirmation, often with field glasses. The infected area is plotted on the maps or photographs and checked on the ground. This work was begun in 1949 and continued in succeeding years. By 1951 about 25,000 mi had been flown over approximately 740,000 acres using this method of detailed mapping.

Ocular estimating of damage. The second major procedure included in visual scouting is ocular estimating. In this procedure the pilot flies along predetermined grid lines drawn on the map, while the observer watches the ground through a peep sight and counts stricken trees as they come into his field of vision. This is a sampling procedure that results in an estimate of total damage but gives little information concering specific locales for control operations. It has been used in bark beetle surveys in the West where individual tree counts are required.

Operation recorder. The third procedure involves use of an operation recorder (*12*, *15*), an apparatus that moves a continuous paper belt at a constant rate past a battery of pens. The pens are controlled by buttons. When a button is pressed, the corresponding pen contacts the paper belt and remains in contact until the button is released. Thus a line of length corresponding to the time the button is depressed is drawn on the paper.

In practice, the operation recorder is used as shown in the following example of a survey for spruce budworm damage in northern Maine. A base map of the area was prepared with a grid of flight lines. These lines were 3 mi apart, ground distance, and extended from the eastern border of Maine to the western border. The plane, a Cessna 195 with floats and full length Plexiglas doors, was then flown along the flight lines at 90 to 95 mi/hr at a constant 200 ft above the treetops. The constant altitude was maintained with the help of a radio altimeter. A 20-pen recorder was used. Two observers, one on each side of the plane, simultaneously recorded the presence of any of six conditions on the ground below. These conditions were (i) no observed defoliation, balsam fir present but no damage visible; (ii) scattered defoliation, individual trees browning; (iii) continuous de-

foliation; (iv) continuous hardwoods that are not susceptible; (v) open fields; and (vi) open water. In order to define the position of the various condition classes, the pilot recorded on the tape the time that the plane passed over certain selected check points. Since the ground distance between check points was known, the map scale of the record on the recorder belt could easily be computed by comparing the belt distance with the ground distance. The information on the belt was then transferred to the base map. Under these conditions defoliation in excess of 15 to 20 percent could be detected. In one season, a representative sample of 10 million acres in northern Maine was flown in 2½ wk. Flying time was 44 hr, of which 22 hr were actually spent on the flight lines. Personnel consisted of one pilot, two observers, and one draftsman. The cost of this survey was 18 ct/1000 acres.

The U.S. Department of Agriculture's Bureau of Entomology and Plant Quarantine has been using this procedure in Maine since 1950 for spruce budworm evaluation. A modification of the procedure was used in Minnesota for larch sawfly (*Pristiphora erichsonii* Hart) damage appraisal in 1951. There the plane was flown at a higher altitude and speed to provide a wider swath, thereby reducing costs to 9 ct/1000 acres.

Road strip survey. The fourth, and last, of the visual scouting procedures is an aerial adaptation of the automobile reconnaissance. This has been given the name of road strip survey (*15*). As in the automobile reconnaissance, existing roads are selected to be examined. The plane flies over the roads at 90 to 100 mi/hr and 150 to 200 ft above the ground. Two observers, one watching each side of the road, look for infested trees. Any trees so located are marked on a large-scale highway map and later examined on the ground. This procedure is superior to the conventional automobile survey because of its greater speed and because a much wider swath can be seen from the plane. Infected trees can often be more easily spotted from the air than from the ground. The procedure has been used in surveys for oak wilt damage.

The use of aircraft in detecting damage caused by forest pests has certain limitations. The major limitation is that only such symptoms as defoliation or deadening of leaves, causing "red tops," can be seen from a plane. The Englemann spruce beetle is a good example of a pest whose activities cannot be detected from the air until the tree dies, which is obviously too late for effective control. Many insects and diseases have symptoms that can be seen from the air, but the identification of the precise causal agent depends on the experience and skill of the observer. For example, "red tops" in southern pine may be caused by either southern pine beetles or engraver beetles (*Ips* spp.). In western white pine (*Pinus monticola* Dougl.), "red tops" may be caused by either pole blight or white pine blister rust (*16*). In balsam fir and spruce stands, "red tops" may indicate spruce budworm damage or winter damage; or, in season, they may merely indicate the appearance of staminate flowers on balsam fir (*12*). Still another example in the balsam fir forests is a "chewed" or "ragged" appearance of the fir that could be caused by either spruce budworms or black-headed budworms (*Peronea variana* Fern) (*12*). In the first three cases, it is felt that satisfactory identification can be made from the air by properly qualified observers, but it should be confined by ground checking. In the last case, however, identification cannot be made from the air.

A second limitation to the use of aerial scouting is the difficulty in detecting incipient attacks. If such attacks could be detected, the problem of planning control operations would be eased considerably. Usually, however, the damage approaches serious proportions before anything can be seen. In the case of spruce budworm, defoliation must exceed 15 to 20 percent before an attack can be detected from the air (*12, 19*). Attempts have been made to arrive at rules of thumb to predict the extent of incipient attack surrounding a noticeable attack. This has been done with the southern pine beetle in Mississippi, where a relationship was found between the total infested area and the area showing "red tops." The probably infested, but as yet unfaded, area could be sketched in on a map after the visible areas had been located from the air. These limitations, although serious, do not prevent the use of aerial scouting. Used under the right conditions, the procedures described yield usable information at relatively low cost and with great time savings.

Aerial photographic methods. Aerial photographic methods of pest detection have not proved as valuable as visual scouting. There are several reasons for this, mostly economic. A forest insect or disease attack is dynamic. The situation changes constantly. To be useful, therefore, aerial photographs must be current. Photographs more than a few weeks old are often useless. The area must be rephotographed to record the new conditions. Rephotographing an area, especially a large one, is expensive and may cost as much as the control operation itself. If photographs are to be useful for pest detection, they must be taken at large

scales. This means that a smaller area of ground is shown on each photograph than in the case of conventional medium- or small-scale photography. In turn, this means higher per-acre charges for labor and materials, through every step of the operation from the actual flying to the interpretation, than would be the case with conventional scales. This additional cost for large-scale photography raises the per-acre cost of aerial photography to the point where it cannot compete with visual scouting procedures.

In addition to the high costs of large-scale photography, there are other factors that increase the cost even more. It has been found that black-and-white film, either panchromatic or infrared, does not give satisfactory results. The best results are obtained with color film. Color film costs 4 to 5 times as much as black-and-white and takes 3 times as long to process. A 7- by 9-in. color contact print costs about $8, whereas a black-and-white print of the same size costs 50 ct (*20*). It can be seen that there are stringent economic limitations to the use of aerial photographic methods of pest detection.

Attempts are being made to overcome this problem. Aerial photographs have been taken along strips similar to cruise lines in a timber cruise in order to sample the area. This has been done on an experimental basis in Maine by the Division of Forest Insect Investigations, Bureau of Entomology and Plant Quarantine, U.S. Department of Agriculture, to evaluate spruce budworm damage (*15*). It was found that such a photo survey would be more extensive and less expensive than a ground survey, but it was decidedly inferior to the visual aerial scouting method. In this case it was found that color photographs (Ektachrome Aero) at a scale of 1: 2400 gave the best results.

The Division of Forest Insect Investigations has also tried mapping southern pine beetle damage using 100-percent stereoscopic coverage (*15*). At standard forest-management scales (1: 15,840 or 4 in. = 1 mi.), infested stands could be delineated from healthy stands on color photographs. At all scales panchromatic photographs gave unreliable results, and infrared photographs proved useless. The *best* combination, *disregarding costs*, proved to be color photographs at a scale of 1:4800. Even incipient damage could be detected under these conditions. When costs must be balanced against performance, this scale is too large and the smaller 1:7920 (8 in. = 1 mi) scale is recommended.

Still another experiment involved the evaluation of white pine weevil (*Pissodes strobi* Peck) precontrol and postcontrol damage in eastern white pine (*Pinus strobus* L.) plantations in the Northeast (*15*). Here again color photographs at large scale (1:1200) proved useful, whereas the black-and-white photos were of little value. The aerial photographic survey cost approximately one-half of that of a comparable ground survey when all costs were included. Thus it becomes evident that there are potentialities in the use of aerial photographs in forest-pest detection, but as yet there are many problems that must be solved. The chances are that aerial photographs will never supplant the visual scouting technique, but they may well supplement it in certain cases.

Aerial photographs are, however, finding wide use in insect and disease detection and control for purposes other than detection itself. They are often used as the base on which to sketch the outlines of infestation that is being visually scouted from a plane. They also find wide use as extremely detailed map substitutes in planning operations. Studied stereoscopically, they reveal much otherwise hidden information, such as routes of access into likely areas for ground observers or control crews (*9, 21, 22*), areas of blowdown, and stands of susceptible timber. As in the case of the aerial visual scouting technique, it is essential that the photo-interpretation be checked on the ground.

Another use of aerial photographs in pest control is recording conditions for propaganda purposes (*18, 22*). Control operations are expensive, and authorization for the needed expenditure of funds must usually be given by boards of directors or legislatures. Such groups of people are often unaware of the seriousness of the problem, and the seriousness must be brought home to them. A very effective tool for this is provided by low-altitude, oblique photographs in color. With such photographs a highly effective appeal for funds can be made, especially when a series of photographs are used to show the intensification and spread of damage by a pest. This was done in 1951 to emphasize the seriousness of pole blight of western white pine.

Forest-Pest Control

After the presence of a pest has been detected and the location, size, and rate of spread of the attack have been determined, control measures must be considered. There are two basic classes of control measures, direct and indirect (*23*). Direct control is aimed at suppression and applies mostly to insects. Until recently, it has had little application in forestry because of costs involved. Direct control measures include (i) mechanical methods

—collecting, trapping, destroying infested material, and barking to destroy broods; (ii) biotic methods—parasites and predators; and (iii) chemical methods—dusting and spraying.

Indirect control is aimed at influencing environmental factors to limit the spread and activity of an insect or a disease. These control measures include (i) chemical and mechanical methods of modifying food supply, moisture and/or temperature conditions; (ii) biotic methods of increasing competition by the introduction and encouragement of parasites and predators; (iii) silvicultural methods of regulating the composition and density of stands, selection of sites, and selection of resistant varieties and species (silvicultural methods traditionally have been the forester's chief weapon against pest attack and still remain the most important), and (iv) statutory regulations of quarantine, embargo, inspection, and certification.

The aerial application of insecticides or fungicides is a method of direct control. Its first use to control a forest insect was in 1921, when a small infestation of the catalpa sphinx (*Ceratomia catalpae* Bvd.) in Ohio was dusted with lead arsenate from an open cockpit biplane (*8*). The method was used in 1928 against the hemlock looper (*Lambdina* spp.) (*23*). In 1938 autogiros were used against cankerworms (*Alsophila pomentaria* Harris and *Paleacrita vernata* Peck). The results varied. Insects were killed, but there were serious shortcomings. Air currents prevented even distribution of insecticide. Dusts did not stick to foliage and were easily removed by rain or wind. Because of the large amounts of dust that were required, costs were high, about 5 to 7 dol/acre. Large-scale operations could not be carried out because sufficient quantities of arsenicals were not available (*23*). Thus the method marked time until the development of DDT, which during World War II was used to spray whole islands in the South Pacific for mosquito control. After the war, DDT was used more and more in control operations against forest insects. At first the jobs were small; but they kept increasing in size until, in 1947, 413,000 acres in the Northwest were treated for the Douglas fir tussock moth (*Hermerocampa pseudotsugata* McD.) (*8, 24*) and 200,000 acres in the East for the gypsy moth (*Porthetria dispar* L.) (*8*). Since then, even larger areas have been treated in the North and West for the spruce budworm and in the East for the gypsy moth (*25*). Insects now being treated include the spruce budworm (*8, 19, 26, 27*), gypsy moth, hemlock looper (*19*), Douglas fir tussock moth (*8, 24*), pine sawfly (*Neodiprion* spp.) (*19*), Saratoga spittlebug (*Aphrophora saratogensis* Fitch) (*8*), and the pine colaspis (*Colaspis pini* Barber). One of the most recent research projects in aerial spraying involved application of a parasitic virus to an infestation of the pine sawfly in Alabama. In another experiment, a silvicide, CMU, was sprayed on trees infected with oak wilt and on a band of apparently healthy trees surrounding them in order to seal off the infection. The results of these two experiments are as yet unknown.

The chemical most commonly used in aerial spraying of forests is DDT, which is very effective within certain limitations (*8*). It is satisfactory only against free-moving defoliators. Slow-moving defoliators are less exposed to direct contact and do not eat as much treated foliage as the faster moving insects. DDT is lethal to bark beetles; but, as yet, no method has been devised by which it can be applied to the surfaces of tree trunks from the air. In order to kill bark beetles with DDT, it is necessary to spray the bark thoroughly. DDT cannot be used indiscriminately. The forester and forest entomologist must know the habits of the insect involved and modify their attack to take advantage of any weaknesses.

DDT works best in solution. It is dissolved in a naphthenic hydrocarbon, and this solution is then diluted with No. 2 fuel oil. The usual dosage is 1 lb of DDT in one gal of fuel oil per acre, but in some cases the concentration may go as low as ¼ lb of DDT in 1 gal of fuel oil per acre. When a watershed is treated and fuel oil might taint the water, the solvent used is xylene and the dilutant is kerosene. This combination is less desirable than the standard because of increased fire hazard (*8*).

Emulsions and suspensions of DDT have been tried, but they have not proved satisfactory. Emulsions have two serious defects. They cannot be exposed to freezing weather, and they are more toxic to aquatic animals than solutions are. Suspensions of wettable powders are not satisfactory because they tend to clog the spray equipment. Colloidal suspensions may be more useful, but they have not yet been evaluated (*8*).

The aircraft normally used are two-place military trainers (Fig. 3). The N3N and PT-17 are very common, and other planes such as the Travelaire 4000 are also used. These planes have satisfactory performance to about 5000 ft with standard 200 to 235-hp engines. Tanks with capacities of about 80 gal of insecticide are usually mounted in the front cockpits (*8, 24, 25, 28, 29*).

Light aircraft of the Piper J-3 or Aeronca Champion category have been used in some cases,

Fig. 3. Stearman plane applying spray over pine woods. [USDA, Bureau of Entomology and Plant Quarantine photo]

but have not been satisfactory because of their limited payload of about 25 gal.

Multiengined aircraft, such as Douglas C-47's, Boeing B-18's, and Ford Trimotors, have been used in some large-scale operations where conditions were favorable (*8, 24, 25, 29*). The Canadians have used Canso twin-engined amphibians (*26*). In the first three planes the insecticide is carried in fuselage tanks of from 400- to 1000-gal capacity; in the amphibian one 625-gal wing tank is used. These heavy aircraft are used when the distances from the airport to the spray area are long and the terrain is relatively flat. They are not adapted to twisting around at low altitudes in rugged canyon country.

Helicopters have been used on some small, specialized jobs, and they have shown promise. The Bell 47B-3 and 47D (agricultural model) have been most widely used (*28, 30*). Their load limit is about 55 gal of insecticide, which is carried in two tanks attached to the sides of the fuselage. This payload is small; but the aircraft can be refilled right in the spray area, and little time is lost. Pressure ceiling limitations have a strong effect on the payload limit and may prevent the use of the helicopter at high altitudes. Probably the most serious deterrent to the use of helicopters is the high operating cost. Aside from cost, application by helicopter is usually about as effective as application by light plane; in special situations, however, the helicopter may be superior. For example, in some cases, the rotor downdraft makes distribution more uniform by blasting spray down to the ground, where it is bounced back up onto the underside of the leaves. The helicopter is being used mostly for small areas such as plantations and small spot infestations.

Spray apparatus is still being developed, but several basic designs have been accepted and used under different conditions (*8, 24, 29, 31, 32*). The Bureau of Plant Industry, Soils, and Agricultural Engineering and the Bureau of Entomology and Plant Quarantine, both of the U.S. Department of Agriculture, have cooperated in considerable research and development of spray apparatus. Among the basic designs, probably the most com-

mon is the suspended boom (Fig. 4). This consists of a lateral pipe mounted under or behind the wing and fitted with nozzles at intervals along its length. Such booms have been designed for a variety of aircraft, such as the Stearman N2S biplane, the Piper J-3, the Douglas C-47, and the Bell 47B helicopter. Although all are pressure fed, only some are capable of handling emulsions or suspensions. The nozzles differ somewhat from those used in general agricultural spraying in that the forestry nozzles usually have somewhat larger orifices. This is necessary because forest spraying is done from a greater altitude than agricultural spraying is. The nozzles can be plugged in order to control the spray output or dosage rate. It has been found that spray particle size can be controlled by the angle at which the liquid insecticide is jetted from the nozzles into the slipstream. If the orifices face forward, particle size is much smaller than if they face to the rear, in which case the insecticide just streams away without being broken up by the wind. The smaller particle size is usually desired, since it results in a somewhat more uniform coverage.

Another spray-distribution device is the wing-tip nozzle. Such a device has been installed on a Stearman N2S biplane. Nozzles at the ends of the wings are fed through pipes connected to a wind-powered, gear-type pump. This pump will handle solutions and emulsions but not suspensions. The nozzles produce a flat spray, and the discharge rate can be varied by using nozzles of different sizes. This device has been used successfully for forestry purposes, but it is not adapted to general agricultural applications. It is said that with the addition of a double nozzle of the same type under the tail of the plane, the device can be used for field-crop spraying, since this completes the distribution pattern even at low altitudes, but some authorities on crop pest control do not agree. The main advantage of the wing-tip nozzle over the suspended boom is reduced drag.

The spinner disk has been developed to disperse heavy emulsions and suspensions that cannot be used in some pumps or spray systems. Such a device has been mounted on a White Standard biplane. A 110-gal tank mounted in the front cockpit is connected to a crossboom extending out 3 or 4 ft from the sides of the fuselage behind the pilot's cockpit. The dispersal units attached to the ends of these booms, are propeller-driven double disks that rotate at relatively high speed. Insecticide is pumped into the gap between the two disks and spun out into the air in the form of small droplets. The slipstream further agitates the air and helps keep the droplet size small. The device has been used successfully with DDT, lead arsenate, and cryolite in concentrated form.

The three distribution systems described are the ones most commonly used, but others are in existence. Some of these employ spinning brushes and others Venturi tubes to disperse insecticides.

Fig. 4. Stearman plane fitted with dual spray apparatus. [USDA, Bureau of Entomology and Plant Quarantine photo]

Relatively little has been published concerning the use of these devices against forest pests, but in a recent book, A. W. A. Brown indicates that spinning brushes have proved quite successful against mosquitoes over large areas in Canada (*33*).

Problems of aerial application to forest insects are somewhat different from those of application to general agricultural pests because of the large areas involved, the irregular terrain, the uneven heights of the trees, and the organization of the operation (*8, 24, 25, 28–30*). Considerable advance planning is necessary. The area to be covered is first divided into natural blocks, such as watersheds or blocks bounded by roads. Each block is then considered an individual unit. When the terrain is flat, the lines are flown in a grid pattern; but in rough terrain the flying must be done along either the contour or downslope. The swath width determines the spacing of the lines, and in turn it is controlled by the type of aircraft being used. Light planes of the Piper J-3 class cover a 60- to 100-ft swath; trainers such as the Stearman N2S cover 100 to 200 ft, and multi-engined craft cover 300 to 600 ft. A distinct problem is spacing these lines so that the insecticide is properly distributed. The aerial applicators sometimes set up captive balloons, wind socks, or flags to mark the ends of the lines. This is difficult to do in rough terrain; and, as a result, more emphasis must be placed on the pilot's judgment. Attempts have been made to mix dyes with the insecticide so that the treated area would show, but the results were unsatisfactory.

The altitude and speed of flight are dependent on local conditions and type of aircraft. Usually, trainers are flown at 80 mi/hr 50 ft above the treetops, and release 20 gal of insecticide per minute in a swath 100 to 150 ft wide. Heavier aircraft are flown at higher altitudes and speeds. The Douglas C-47 is flown at 150 mi/hr 150 to 200 ft above the treetops, and releases 150 gal/min in a swath 500 ft wide. Rough terrain will force the planes to higher altitudes. To avoid turbulence and excessive wind that would prevent even distribution of the insecticide, flying is limited to early morning. The usual rule is to stop application when the surface wind exceeds 10 mi/hr.

Operation planning must be based on a thorough knowledge of the insect's life-cycle, since in most cases the period of optimum susceptibility to the insecticide is short. The entomologists must keep a running check on the stage of development of the pest; and, when the time for application has come, the spraying operation must move unhindered to take advantage of the available time. If the operation is large, as in the case of some of the spruce budworm jobs, there may be enough range in altitude and latitude to make it possible to stagger the operation so as to control the insect on one area and then move to another area where it is just reaching the susceptible stage. This presupposes, of course, a thorough knowledge of the insect's life-cycle and the variations in that cycle caused by local conditions.

The necessity for utilizing very short periods of time makes operation planning a big and complex job. In a big operation, such planning takes on many of the aspects of a major military operation. As in the case of a military operation, the first job is the accumulation of reliable information. In forest-pest control this information deals with the extent and rate of spread of the infestation. This is obtained by aerial or ground reconnaissance and reveals what areas are involved. The second step is to assemble the interested landowners to discuss any legal questions that may arise and to agree on assignment of costs. It is here that the new federal Forest Pest Control Act begins to show its usefulness, since it provides a framework on which to construct the operation. The third step is the operation planning itself. Everything down to the last detail is planned so that all that remains for the pilots to do is to follow instructions. This includes (i) setting up radio and telephone communication networks and weather stations throughout the area; (ii) analyzing past weather behavior to determine the best times for flying and probable periods of lost time owing to weather; (iii) preparing airfields and flight strips, along with necessary auxiliary facilities such as fuel and insecticide storage, pumping equipment, and maintenance shops and equipment; (iv) contracting for insecticide and arranging for transportation by railway or truck from manufacturing plant to storage area (in some cases this requires special arrangements with the railroads so that the insecticide is given high priority in order that the spraying operation is not slowed or stopped because of a lack of insecticide); and (v) contracting for planes and pilots and checking the equipment to see that it meets specifications for the job and is properly adjusted.

When the time approaches for the spraying, the local residents are warned so that they can take measures, such as hooding apiaries, to prevent loss or damage from the insecticide. The entomologists are sent into the field to keep a running check on the development of the insect. The field weather and communications stations are manned and ready. When the word comes

from the entomologists that the time has come, the control operation begins. As the spraying goes on, the entomologists keep a check on the spray distribution by laying oil-sensitive cards across the spray runs. If any cards show scant or excess insecticides, the pilot is immediately notified. In this way a tight control is maintained over the whole operation. When an area has been sprayed the entomologists check the kill and determine the efficiency of the operation. Relatively few private organizations have the personnel or resources to carry out such an operation. For this reason, the Forest Pest Control Act has been, and will continue to be, of great assistance to forest landowners, since it makes available the immense technical and financial resources of the Federal Government.

Such an operation as described is economically feasible, provided that the insect can be controlled by DDT. The cost ranges from 1 to 3 dol/acre, depending on such factors as terrain, size of area, distance from landing strips, and dosage rate. In 1947, 350,000 acres of Douglas fir in Idaho were successfully treated with DDT for tussock moth at a cost of 1.57 dol/acre. In New England and New York, the gypsy moth has been eradicated over large areas at a cost of 95 ct/acre. The spruce budworm has been widely treated in this manner. Between 1949 and 1952, 2,793,000 acres were treated in Oregon and Washington. In the North and in Canada kills of about 97 percent have been claimed in heavy infestations of this insect. Continuing annual operations are planned where needed.

Conclusions. It can be seen that aircraft have become increasingly important in the detection and control of forest insects and diseases, but that they are not yet the complete solution to the problem. Visual aerial scouting methods are extremely useful in detecting damage caused by certain types of insects and diseases whose symptoms show up early. Aerial photographic detection methods have not proved practical in the past; but recent research indicates that at least in some cases large-scale color photography will pay dividends. Last, the development of new insecticides such as DDT has made aerial application to large areas of forest lands economically feasible. It is indicated also that there may be a future use for aerially applied herbicides or silvicides in combating forest diseases. There is now a distinct trend toward the development and application of practical procedures for protecting our forests from insects and diseases. The lag between this type of forest protection and comparable fire protection is beginning to shorten; and it is to be hoped that eventually both causes of damage to our forests will be brought under control.

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The Preacher Talks to the Man of Science

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Dr. Rasmusson prepared for the ministry at McCormick Theological Seminary and the Chicago Divinity School. He also studied at St. Olaf College and Yale University. Since 1945 he has been minister of the University Presbyterian (All-Student) Church at Purdue University, Lafayette, Indiana, and director of the Westminster Foundation connected with the church. Dr. Rasmusson has lectured on religion at Purdue, has conducted programs on the university radio station, and has lectured in many parts of the United States. He is particularly interested in the problems of family living.

RELIGION and science have certain things in common (*1*). For one thing, both begin with faith or, if you prefer, a "basic acceptance." It is one of the superstitions of some people that religion uses faith but science does not. These people naively assume that religion, in using faith, is sentimental, romantic, and characterized by wishful thinking but that science is logical and realistic. That some forms of religion can be so judged I do not deny. I do deny it for all religion.

Thomas Huxley once said:

> Religion says that the just shall live by faith. Science says that the just shall live by verification.

But in reality, this is true for both science and religion.

Max Planck spoke more correctly when he said that over the gates of the temple of science are written these words: "Ye must have faith." Faith that our sense perceptions report correctly what is out there. Faith in the trustworthiness of our mental processes. Faith that there is truth. Faith that it is worth pursuing. Faith that it will be worth finding. As Macneile Dixon (*2*) put it in his Gifford lectures: "Men ardently pursue truth . . . assuming that it will be angel's bread when found." Faith that the universe is orderly and dependable and will be dependable at the moment the scientist performs his experiment in the laboratory.

Is all this a small thing to believe? Without faith, the scientist at the very beginning of his efforts would be paralyzed. Max Planck spoke truth and wisdom: "Ye must have faith." All of us must have faith. Scientists, religionists, all of us in everyday living require faith.

A second thing religion and science have in common is that both confront the universe with intelligent minds and seek to make a reasonable interpretation of experience. The scientist follows up sense-impressions and finds that they lead into an external world which becomes the province of his labors. The religionist finds that there are also, in experience, the dimensions of spirit: aspiration, hope, love, dedication, purpose. He finds that these are every bit as real as sense-impressions and that they lead to an order of reality he calls God. The doctrines of religion, like the hypotheses of science, are the outgrowth of a relationship with the universe and the attempt to make meaning out of experience.

The rationality of the universe is a theory steadily confirmed by the victories of science. The doctrine of God as love, Christ as the way of peace and power, obedience to Him as the road to experience of Him, have maintained themselves through every kind of vicissitude and possess truth for thousands of people who are every bit as hard-headed and practical and realistic as any scientist.

As the scientist acting by faith in the theory of the uniformity of nature, its orderliness and dependability, wins assurance of its truth by its fruit, so the man of religion acting by faith in the doctrine of God as love, Christ as His Revealer, His spirit as the solvent of hate and ill-will, the road to peace and purity, wins assurance of its truth by its fruit. Jesus said: "By their fruits ye shall know them."

Religion says to man about Christ: "Make the experiment and you will have the experience." You will know this religion by what it does in you. It is not blind faith. It is faith as adventure—daring to do the Will.

Religion of the Christian variety is faced by a

hard fact. Winfred Kirkland has somewhere written:

> There is a Man here who says: "I have the secret of life. Come and live with me and see if I am true. It is the law of my reality that you cannot know me by looking at me. You cannot know me except by the scientific adventure of an hypothesis."

Jesus said: "If any man will do my will, he shall know" about the deeper truth of life. We too must make sense out of this fact. Doctrines rightly apprehended are the rationale of this kind of experience.

Third, both science and religion have those within it who are poor examples of its spirit. There are scientific fundamentalists just as there are religious fundamentalists. William James once asked why some scientists "gulped everything materialistic down as peculiarly scientific."

What is the difference between a scientist who dogmatically asserts that the natural order is a closed system and sufficient unto itself, ruling out any transcendent meaning in life and a religionist who asserts the verbal inspiration of the Bible and pronounces his anathemas on all who will not with him believe the Bible from "kiver to kiver"? Bigotry and intolerance can wear the face of either science or religion.

The true spirit of science is open-minded examination of all sides. To begin with, an antireligious bias without fair, humble study of all the relevant facts of religion is unfair and unscientific. And for religion to invade the field of scientific investigation and pronounce against well-founded facts of science is to be irreligious. The world suffers today from both bad religionists and bad scientists.

Jesus said to professors of religion: "Why call ye me Lord, Lord, and do not?" We do fall far short of our creeds; but scientists often do too.

Some scientists dogmatize that only that which can be measured by a slide rule or tested in a crucible is truth. Such a scientist deals with the universe on a fragmentary basis but makes judgements about the whole from a study of the part. He forgets that many aspects of reality elude this method. Science reduces the world for the purposes of description and this is necessary; but some forget that for this very reason we must supplement science. Feeling is also a pathway to reality. Art is also an avenue to truth.

And as the religionist fails to deal with his fellow men in the spirit of his religion of love, so often the scientist fails to show the scientific temper in fields outside his specialty. Said a Purdue professor (*3*) at a conference some years ago:

> This abandonment of the scientific method by many scientists, when they close the door of their laboratory, reminds one of the pseudo-religionist who goes to church on Sunday and then grabs all he can on Monday.

To one and all Jesus says: "Repent for the kingdom of heaven is at hand." This message we all need—scientist and religionist alike. How many are the things we have in common: faith, method, even failure. May religion and science work ever more harmoniously together.

Then there is science and scientism.

Science involves a method—observation, experiment, hypothesis, further experiment, and checking, and so on. It is a search for empirical knowledge. Thomas Huxley wrote to Charles Kingsley (*4*):

> Sit down before fact as a little child, be prepared to give up every preconceived notion, follow humbly wherever and to whatever abysses nature leads, or you shall learn nothing.

Our debt to empirical truth-seekers is immense. Technology is an offshoot of science and this spirit, and our material abundance is its fruit. It has made—and is making—many things more available and available to more people at more popular prices.

Scientism, on the other hand, is a cult that has made a religion out of science. It is committed to the laboratory method of truth. Science deals with "observable, countable, weighable reality"; but scientism imposes a "dogma, a frame of reference on reality" and says in effect that "the laboratory method is the only way of getting at scientific truth and therefore any conviction arrived at otherwise is not truth" (*5*, p. 44).

The true scientist does not say this. But the devotee of scientism does say it. But it is dogmatism pure and foolish. And when it is propagated as a "faith" or a "creed," that is one thing. It has the right to be propagated. We believe in freedom of the mind. But when taught as science, that is another matter. And students should know the difference. As a recent book puts it (*6*):

> The faculty of philosophy which is loaded with naturalists and positivists doing lip-service to science propagates opinions and interpretations, not scientific knowledge. The philosophers of scientism are not objective or scientific; they hold to a faith of their own. [And this faith is] abandonment to a single means of looking at the world and of understanding life's nature and meaning.

And what about the qualitative in life? Scientists should not let their passion for order and system and measurable truth cause them to forget the truth that cannot be measured by the methods of science. I understand that passion for precise measurement, system, and order are part of the life-blood of science. And while we wish scientists full sail ahead, they ought never to forget that their very zeal for order and system may cause them all unwittingly to ignore aspects of reality that the net of science cannot catch. One can be so enamored of the quantitative approach to reality that he forgets or even ignores the qualitative approach.

What is a sunset? Science can analyze the colors of the sunset and explain its beauty in terms of light waves and, via astronomy, explain the planetary movements that bring on the dusk. Some poet unknown to me writes:

> I've dreamed of sunsets when the sun, supine,
> Lay rocking on the ocean like a god,
> And threw his weary arms far up the sky
> And with vermilion-tinted fingers,
> Toyed with the long tresses of the evening star.

It would be absurd to ask which is truer. They are not contradictory. Both are true—each from its own angle.

Someone once defined a violin solo as "the scraping of a horse's tail across the guts of a dead cat." This may in some sense be science. But Fritz Kreisler playing a violin concerto is something else. Some of the richest aspects of reality are beyond the reach of scales, test tubes and foot-rules. Sir James Jeans, a great scientist, puts it:

> Science fishes in the sea of reality with a particular kind of net called the scientific method and there may be much in the unfathomable sea which the meshes of science cannot catch.

Oscar Wilde, the poet, writes:

> Already the shrill lark is out of sight,
> Flooding the waves of song the silent dell,—
> Ah! there is something more in that bird's flight
> Than could be tested in a crucible.

Finally, remember that science is rooted in a moral order of reality it did not create. Where would science be without the passion for truth and its everyday dedication? Where would it be without the self-denial and splendid integrity of its saints? Science is possible because there is honor among scientists, refusal to prostitute evidence, courage to report data with integrity. But whence this spirit? Whence this passion and honor and devotion?

The scientist is under obligation to a higher loyalty, to something regal in the universe, which he did not create but must obey. But this makes sense only as we see him encompassed by a moral order of righteousness, generating in him and his fellow-scientists the sacrificial, dedicated integrity that science builds on. This spirit comes from something greater than science. Science is not its creator but its debtor. And to many this is a witness to God, the author of the moral order, without which science itself would, like the old soldier, just fade away.

So Archbishop Temple (*7*) says in his Gifford lectures, speaking of the sense of truth as august and compelling:

> This feeling is quite unreasonable if the order of reality is a brute fact and nothing else.

Would science have developed as it has in our Western civilization if it had not been for the Judeo-Christian faith which has soaked the minds of scientists with the sense of the worth and significance, yes, the importance of human enterprise?

> Science depends ultimately upon some religious faith as to the tractability and reasonableness and goodness of the created order (*5*, p. 31).

Science and religion should not be antagonists. They ought to be allies both in the mastery of life for Christian ends and in the understanding of life. Einstein has said: "Religion without science is blind. Science without religion is lame." As Paul wrote to the Christians at Thessalonica: "Test everything; hold fast to what is good."

References and Notes

1. This article is based on some thoughts shared with a congregation of students on the Purdue University campus, most of whom are majoring in some area of science. It was suggested that these ideas be shared with a wider public. Reaction, favorable or unfavorable, will be welcomed.
2. M. Dixon, *The Human Situation* (Longmans, Green, New York, 1937), p. 18.
3. M. G. Mellon, *Science* **97**, 361 (1943).
4. H. Peterson, *Huxley, Prophet of Science* (Longmans, Green, London), p. 128.
5. J. A. Pike and J. M. Krumm, *Roadblocks to Faith* (Morehouse-Gorham, New York, 1954).
6. E. LeRoy, *Science and Christian Faith* (Association Press, New York, 1950), p. 39.
7. Archbishop Temple, *Nature, Man and God* (Macmillan, New York, 1949), p. 250.

Ehrlich, Biologist of Deep and Inspired Vision

IAGO GALDSTON

Dr. Galdston, who is executive secretary of the Medical Information Bureau, New York Academy of Medicine, is a psychiatrist, a medical educator, and a medical historian. He is the author of a number of books, including Behind the Sulfa Drugs, *a historical account of the scientific developments that have yielded modern chemotherapy and the antibiotics.*

THE one-hundredth anniversary of the birth of Paul Ehrlich was celebrated on 14 March 1954, in Frankfurt, in London, in New York, in Washington, and most probably also in other world centers. Thus was a great man's memory honored by a mindful and grateful world. Mindful and grateful? Only in a modest degree, for to be frank, it is doubtful that the average man, the effective atom of the world mass, had any awareness either of the anniversary or of the man. The Sunday editor of a great cosmopolitan paper whose readers number in the millions could not fit an article on the occasion into his "crowded" schedule and politely declined help from among the dwindling few who knew Ehrlich as "person and scientist." And truth to tell, Paul Ehrlich is not quite the man to catch or to hold the public's fancy. Once you have treated of his "magic bullets," you have disposed of the greater stock of his popular enchantment. The layman knows of Ehrlich as the discoverer of salvarsan, and the number 606 carries for him some suggestive implications. But beyond that he knows little of Ehrlich's manifold ventures into the unknown.

The discovery of prontosil and the subsequent development of the sulfonamides "resurrected" chemotherapy and refurbished the fame and memory of Paul Ehrlich, for those who attempted to trace the development of modern chemotherapy, myself among them, could not but dwell on Ehrlich and his great works. But then came the discovery and the phenomenal development of the antibiotics, and, as a result, many were persuaded that chemotherapy was a thing of the past. The public and many physicians do not associate Ehrlich with the antibiotics. They think of Ehrlich only as a chemist. They are not mindful of Ehrlich the biologist, the man of deep and inspired vision. It is this phase of Ehrlich's life and work I would underscore, for in the panoply of medical history there are many good scientists but few inspired men. Ehrlich is one among them and he brings to mind, as his coequals, Paracelsus and Freud. They, too, were inspired men—seers.

Paul Ehrlich is the embodiment of all the knowledge and wisdom that enter into chemotherapy. The pinnacle of his fame is salvarsan, the arsenical that he created and that was in effect the first great modern therapeutic agent. But that pinnacle tops vast achievements founded upon broad knowledge and experience. Paul Ehrlich's was a catholic intelligence, one that illumined whatever it dealt with. There is enough glory in his life's work to have assured fame to a score of men, and enough inspiration in his unfinished work to feed the imagination and to nourish the curiosities of several generations. We know him principally as a chemist, as the man who converted a chimerical dream into a lifesaving reality. We are prone to fancy him puttering among his chemicals, trying with devoted patience and unflagging faith, now this, now that combination, one, ten, a hundred different ones, until the 606th yielded him the alchemist's dream, the great elixir. But true as this fancy may be in detail, it is faulty in representation. The man is not to be seen either in the way of his work or in its fruits. He can be perceived only in his thought, in the inspiration that guided it, in the light that made it luminous.

Ehrlich was more than a chemist. He was a biologist in the profoundest sense of that term. He had a long and thorough apprenticeship in the fundamental biological sciences, and to each he contributed precious new knowledge. He traveled the long road and all the bypaths that led to chemotherapy and toiled with every step. His crowning achievement was not a gift from the gods, not a lightning stroke of genius, not a for-

tunate inspiration. It was rather a precious nugget reduced in the crucible of long and hard toil. His Faustian spirit sought for knowledge in many spheres, in the respiration of cells, in the analyses of dyes, in the fine structures of the brain, among the bacteria and the garden herbs. He quizzed nature on the mystery of immunity and wrested from her some portion of her secret. He dipped deeply into the problem of malignant growths and left upon it the imprint of his thought, so that to this day his theories are respected, and his hypotheses are the signposts of future research. He, who was trained as a physician, proved himself a master chemist, and as both chemist and physician, he gave to man the mightiest weapon with which to combat one of its most malignant plagues, syphilis.

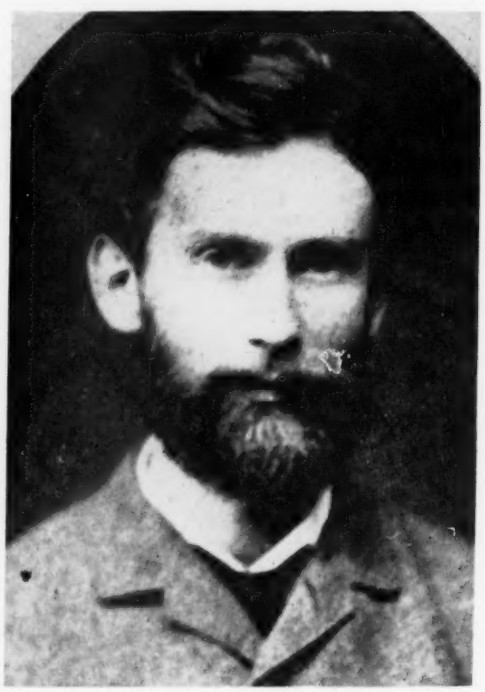
All this is to the good. But to understand the uniqueness of Paul Ehrlich we must begin at the beginning—not with the end. Paul Ehrlich did not set out to become the founder of modern chemotherapy—anymore than George Washington set out to become the father of his country. Ehrlich was the son of a modest family, a Jew, born in the town of Strehlen, Upper Silesia, on 14 March, 1854. His father was an innkeeper, but he was an unworldly soul and a strange character to boot, so the inn was actually tended and managed by Paul's mother. We know little about Paul's parents, and what is told of his childhood and youth is mainly anecdotal. It is all too casual to enable us to see the man foreshadowed. His paternal grandfather is said to have resembled Alexander von Humboldt, and he is reported to have given popular lectures on natural science, at the age of 80.

In his youth Ehrlich was an undistinguished student. He did, however, have a great fondness for the ancient tongue and he peppered his everyday conversation with Latin words and phrases. There was an element of the archaic, something demoniacal, or even cabalistic in the primal personality of Paul Ehrlich. This became manifest quite early and was the signature of his entire life. Ehrlich had no burning ambition to become a healer. Nor did "research" draw him on with the promise of great adventures and greater rewards. Indeed the siren research had not yet come of age.

The first laboratory for the study of physiology was opened by Purkinje in 1824 when he set aside a room in his modest home. Twenty years later the Prussian government provided Purkinje with the more commodious Physiological Institute. Ehrlich was 2 years old when in 1856 Virchow opened his laboratory for the study of cellular pathology.

Since neither research nor the glory and satisfactions of the healer's profession drew Ehrlich to the study of medicine, it is interesting to inquire what did motivate him. We have no precise knowledge on this score. But we have some fair grounds for conjecture. One certain influence was Carl Weigert, his cousin and his senior by 9 years. Weigert, one of the truly distinguished medical scientists of the last century and a man who neither during his life nor since has received the recognition he deserves, had a deep effect on Ehrlich and initiated him in the fascinating study of tissue and bacteria staining.

Most men are exposed to many influences, and the ones that prevail are such as are reinforced by innate predilections. Two manifest predilections are patent in Ehrlich's personality. He was practical, and he had a consuming interest in biology. Ehrlich was not practical in the grubby sense but rather in the sense mirrored in Emerson's counsel "hitch your wagon to a star." He was, in other words, not what we would today term a pure scientist. As a chemist, or better still as a biologist and physician, he was interested in specific, objective, useful results, in diagnostic criterions and procedures, and in remedies and cures. As a biologist he was interested in all phases of the living process, human and otherwise, normal and pathological. But above all Ehrlich was a driven person, driven



Paul Ehrlich as a young man. [Courtesy New York Academy of Medicine]

by his inner daemon. Given these predilections, where better than in medicine could he seek and find fulfillment? But we need to bear in mind one additional factor: Ehrlich was a Jew—and living in Germany. Nominally he was a free citizen, but in reality he was subject to numerous social, political, and professional disabilities. Of all the professions, medicine offered the broadest opportunities and the better prospects for the gifted individual who also happened to be a Jew.

Antisemitism is an ancient and endogenous disease in Germany. In Ehrlich's time Richard Wagner was glorifying the Teuton and calumniating the Jew. In this enterprise he was aided by the Englishman Houston Chamberlin. Neither the widow of Paul Ehrlich nor his children were spared by the Nazis. Fortunately they did escape with their lives.

The government of West Germany celebrated the one-hundredth anniversary of Ehrlich's birth with great pomp and ceremony. In the irony of fate, this celebration was coupled with the centenary of the birth of von Behring—a man whom Ehrlich despised—for von Behring cheated Ehrlich in both "fame and fortune." Von Behring failed to acknowledge Ehrlich's most important contributions to the development of an effective diphtheria antitoxin and, by deceptive manipulations, cheated him in the contract entered into with the Höchst factory, the commercial producers of the diphtheria antitoxin. In a letter to Althoff, director of the Prussian Ministry of Ecclesiastical, Educational and Medical Affairs, Ehrlich, 9 years before his death, described how he was tricked by von Behring:

> I still feel very bitter whenever I think of this time, not because of the heavy material loss, which no longer troubles me, but because of the unfriendly way in which von Behring carried out his plan.

Ehrlich's initial interests ran to mathematics and Latin. Given his daemon, his energy, enterprise, imagination, and genius, one is tempted to speculate in what other fields he might have gained glory had he been citizen of another age, say of Pericles, or of Caesar, or of St. Augustine, or of Copernicus. For genius takes the issues of its day and works in the realm of the prevailing curiosities but always forges transcending results. The age of Ehrlich was preeminently that of the biologist. Ehrlich came upon the scene when the great pioneers had already uncovered the foundation data of modern biology, but even so, there remained vast terrains to be explored; and some among them Ehrlich did explore. Initially the biologists were monists: they sought to lay bare the units primal to the composition, structure, and functioning of the living organism. Hence, the great achievements of Schleiden and Schwann, who in 1838 and 1839 established the cell as the structural unit of both animal and vegetable life; of Felix Dujardin who propounded the theory of the primacy and universality of a common cellular substance, named by him sarcode and later renamed protoplasm by the illustrious Hugo Moll. What a thrilling age it was! To learn of cells, of protoplasm, of nuclei, of cell multiplication. To unravel the great drama of embryology. To feel warranted and justified in enunciating all encompassing dicta, such as "ontogeny is the recapitulation of phylogeny," "*omnis cellula e cellula*," "*corpora non agunt nisi fixata*." The latter was one of Ehrlich's cardinal principles. Therein he affirmed his conviction that chemical bodies remain inert unless they attach themselves to the body cells. This in the popular fancy is the principle of the magic bullet: the missile that seeks out its mark.

Paul Ehrlich, all the popular fancy to the contrary notwithstanding, was not like O'Neill's Emperor Jones—vitally concerned with magic bullets. His was a deeper, broader, more fundamental interest, that of chemical affinities. This problem touches on deep mysteries in life's processes. Why, for example, can one inject diphtheria toxin into a pigeon without any harm or injury to the bird, whereas the same quantity of toxin in a child's body is likely to produce great disturbances and possibly even death. But this was not the order of problem that first intrigued Ehrlich. There were simpler ones to tackle. For example, why does one tissue stain blue and another red? Why does the cell nucleus take one color and the protoplasm another? Different bacteria exposed to the same dyes do not all change to the same hue. Some remain unaffected, others are easily and deeply stained.

Whoever first thought of staining tissues—the innovation is credited to Purkinje—opened in effect new and vast vistas. Fresh tissues are difficult to "see." They are more or less homogenous in consistency, and only the experienced worker can differentiate the various components of the specimen inspected. A hardened—that is, fixed—thin specimen, well stained in contrasting colors, is, however, a joy to behold. But to achieve this it was first necessary to learn how to preserve, how to section, and how to stain. These achievements stand to the credit of several persons but principally to Joseph von Gerlach, who used carmine as a stain (1847), to Wilhelm His, who in 1866 first utilized the mi-

crotome, and to Max Schultze, who improved on the fixing and staining of tissues.

Ehrlich learned the art of staining tissue specimens from his cousin Carl Weigert. Weigert was the first to stain bacteria (1871). He employed the newly produced aniline dyes with ingenuity and striking effects. So impressed and so much intrigued was Ehrlich by this new world of colors and affinities that he sacrificed most everything else to the pursuit of this one study. Fortunately his medical teachers were indulgent, and impressed. They allowed him to putter among his stains and overlooked his weakness in certain required courses. His professor of anatomy, Wilhelm Waldeyer, wrote in his memoirs:

> I saw that I had in Ehrlich an extraordinarily talented scholar. He very seldom asked for advice, but worked almost entirely independently right from the beginning.

Ehrlich's graduation thesis dealt with tissue staining and was entitled "A contribution to the theory and practice of tissue staining."

But it needs to be repeatedly underscored that Ehrlich was not interested in dyes, save as effective means with which to unravel some of the mystery of the living process. One of his earliest brilliant achievements was the demonstration *by means of dyes* of the different cellular and structural constituents of the blood. Thus he enabled the clinician to differentiate the various types of red blood cells and the different kinds of white cells. The science of hematology was thus in effect made possible, for with a sound knowledge of the composition of normal blood it was possible to establish and to define the various blood diseases affecting the red cells, the white cells, and the other blood components.

In line with these studies Ehrlich experimented in vital staining—that is, the introduction of dyes into the *living* organism. Heretofore all staining was practiced on dead tissues. Sections were removed from the animal or human cadaver, were hardened, stained, and studied under the microscope. But the data thus obtained were valid only for devitalized—that is, dead—cells. Ehrlich undertook to stain the living cells. In 1885 he injected frogs with the dye methylene blue. To his delight, he observed that although the dye was distributed throughout the animal's body, the nerve cells were particularly stained. All other cells remained substantially unaffected. This proved of great help to the anatomists, for it gave them an easy means to study the constitution and distribution of the nervous system.

This also was a sovereign demonstration of "chemical affinities." With A. Lippmann, Ehrlich undertook a series of clinical studies in the medicinal use of methylene blue. Logically, since methylene blue stains the nerves, he attempted to treat severe neuralgias. And at times the treatment was effective. He also tried methylene blue in cases of malaria not responsive to quinine, again with some success. In these first ventures in the realm of chemotherapy, Ehrlich's genius stands manifest. It was the abiding mark of all his work. Profound as it was, reaching down to the most fundamental and general of scientific principles, it was none the less always practical. Ehrlich did not merely postulate principles; he also forged tools, practical, valuable, useful tools. He created diagnostic procedures, he uncovered disease entities, he invented laboratory techniques, he resolved chemical problems, he created useful medicaments, and for all this he conjured forth the most elaborate of schemata and the most remarkable of hypotheses. *Mirabile dictu*—these proved no less workable, no less useful than his tests and medicaments. Today, when an effort is made to conjecture how the sulfonamides or the antibiotics "work," it is Ehrlich's scheme and hypothesis that is followed.

In the introduction to Martha Marquardt's biographical sketch of Ehrlich, published in 1924, a work which the Nazis confiscated and destroyed, Richard Koch, professor of the history of medicine at the University of Frankfurt a.M. wrote:

> The first true successor (Nachfahre) of the great Paracelsus is without doubt Paul Ehrlich, in so far at least as the fulfillment of the quest for specific remedies is concerned.

But there is even greater kinship between Ehrlich and Paracelsus. As a scientist, as a searcher for knowledge in life and life's processes Ehrlich was as driven and as inspired as Paracelsus. There was much of the daemon in the inner personality of Ehrlich. He worked almost incessantly. He appeared disorderly and chaotic. He was distracted and forgetful of, and toward, outer things. He was grossly negligent of his health. He was an inveterate cigar smoker. He was possessed by the idea of chemical affinities as the keys to life's secrets.

It is not possible to detail the different research ventures and the many great achievements that stand to the credit of Ehrlich. I can in this brief review only touch on the major segments of his work. His initial work was in the field of immunity. Here he not only achieved the production of an effective antitoxin for diphtheria but also developed the basic principles and procedures by which other antitoxins and antivenins were produced later. In

addition he formulated his famous side-chain theory of immunity, involving the concepts of antigens, amboceptors, antibodies, and so forth, and sounding, as well as seeming, to the uninitiated, quite like an alchemist's brain storm or a witches' brew. Nevertheless even today when the effort is made to account for the way certain chemotherapeutic agents effect bacteriostasis, Ehrlich's schemes are still found to be useful.

Ehrlich was not content with the *deed,* that diphtheria antitoxin could and does neutralize the malignant effects of the toxin produced by the diphtheria bacillus. He wanted to know how and why. How does a toxin injure a living cell? How does an antitoxin prevent such injury? How does the animal body produce an excess of antitoxins and, thereby, gain immunity? He reasoned, brilliantly we now know, that toxins and antitoxins were in the last analysis "a matter of chemistry." He dreamed of producing and attempted to produce in his chemical laboratory something akin to the antitoxins produced in the animal body. He did not succeed, and it is still a question whether any one ever will do just that. But as we have witnessed during the past 20 years we have come a long way toward the realization of that dream.

Ehrlich's work on toxins, antitoxins, and the mechanisms of immunity occupied the years from 1901 to 1904. Thereafter he devoted himself to the study of cancer and of chemotherapy. The latter was his major preoccupation. He sought for a *Therapia Sterilisans Magna*—an ideal chemotherapeutic agent that in one dose would kill off all the infecting parasites without injuring the host. Ehrlich never found that "great elixir." The best he could do was to create salvarsan. But this in itself was a great achievement. Still it did not "sterilize" the infected individual and was not a "one-shot" treatment. On the contrary it proved to be a long, tedious, and not innocuous therapy. It was, however, vastly superior to any remedy previously known.

The discovery of salvarsan involved Ehrlich in a good deal of annoyance and fatigue. The demands for the compound were world wide and enormous. Ehrlich was called on to answer an infinitude of questions and inquiries, to supervise the production of the drug, and to investigate all reported untoward effects. Worst of all he had to meet criticism and calumny. How much all this contributed to his early death is difficult to decide.

Ehrlich was very negligent in caring for his health. He was seemingly of frail constitution, and it is known that at one time in his life he suffered from active tuberculosis. The gathering clouds of

Ehrlich in his laboratory. [Courtesy New York Academy of Medicine]

World War I darkened his last years. He foresaw ruin and disaster for Germany, and for the world. He was loath to die. There were so many ideas in his head which, alas, he would not be able to develop. "*Es wäre ja eigentlich schade, wenn so vieles, was ich im Kopf habe, sang- und klanglos mit mir verschwände.*" On 20 August 1915 he died.

Ehrlich anticipated great developments in chemotherapy. They were not forthcoming for more than two decades following his death. Many who at first shared Ehrlich's expectations became discouraged as the years passed, and the dream remained but a dream. Then in 1935 prontosil was announced to an incredulous world. A decade later there followed the discovery of penicillin. Would that Ehrlich had lived to witness these magnificent realizations of his life's hopes and dreams! He would not have been surprised. They would have been *as he expected.* Nor would he have been surprised to find that cancer too is being "tackled" chemically.

Ehrlich's genius is unfathomable. As he was *inspired,* so is he *inspiring.* This is the stamp of the greater among the great, that they achieved much but that their greatest effectiveness derives from their power to stimulate the imagination of those who follow. This is why Paracelsus remains a living power. This is also the greatness of Darwin and of Freud, each of whom, directed, as did Ehrlich, the thoughts of men, the searching interests of the scientists along new tangents into new worlds of thought, experience, and achievement.

SCIENCE ON

During the past 100 years entomology has become a highly important science in American life. The activities of the U.S. Department of Agriculture are typical of the tremendous strides made in this work. [*All photos courtesy USDA*]

Certain classes of imported plant material are routed through plant quarantine inspection houses where special facilities and trained personnel are available for safeguarding it. There inspectors carefully scrutinize all plants for signs of insects and disease (top). Such inspection began in 1912 when the Federal plant quarantine act was passed. Before that, many injurious insects, such as the hessian fly, came into this country undetected. In most large U.S. post offices, inspectors also examine foreign packages for injurious insects that might be contained in the packing material. Some states, such as Arizona and California, maintain inspection stations for cars and baggage to prevent the transportation of injurious insects, particularly the pink bollworm, across their borders.

Entomologists often need to know how serious a foreign pest might be if it should find its way to this country and where it might flourish. Recently, they devised a bioclimatic cabinet (center) in which any climate, including temperature and humidity, can be simulated. They have used it in oriental fruit fly experiments in Hawaii to determine conditions under which the insect thrives.

On the other hand, entomologists have brought parasites in from Europe to destroy a large number of European corn borers, and these parasites have become an important control factor. When released in infested corn fields, they seek out the borers and lay eggs in or on them. When the eggs hatch, the immature parasites feed on the borers and eventually destroy them.

Because of the contributions bees make to agriculture, apiculturists are continually crossing bees to produce strains that will resist such bee diseases as American foulbrood. Improved instruments for the artificial insemination of honey bees have been developed by USDA entomologists. Here (bottom) the sperm is being injected into the queen by means of a pointed syringe.

In order to determine the effectiveness of DDT

Entomology at

THE MARCH

against fabric pests, the Quartermaster Corps, U.S. Army, and USDA entomologists have conducted tests on Army woolens stored for 5 years under simulated warehouse conditions in an area heavily infested with black carpet beetles and clothes moths. Untreated cloth was severely damaged; cloth treated with DDT was undamaged.

The eradication of cattle ticks has been the result of cattle quarantine and regular dipping of all cattle in vats containing arsenicals (top). Livestock insect pests cost this country about $500 million a year in wasted food, lower production of meat and milk, and damaged hides.

A chemist-entomologist team first developed aerosols in 1941. They found that a solution of liquefied gas and insecticide sprayed through a small hole created a slow-to-settle fog that was fatal to mosquitoes and flies. Aerosols were used during World War II against insect disease carriers and pests in barracks, mess halls, and fox holes, and in recent years they have been developed for civilian use. Here (center) a new low-pressure container is being compared with the first civilian model (upright) and the original experimental bomb.

Methods for controlling insects have advanced remarkably since the days when entomologists could suggest only sanitation, nets, screens, and fly swatters. Insecticides are man's chief weapon against insects, and, when properly applied, they are both economical and effective. Applicators are available to fit almost any control situation—DDT sprays or dusts control Japanese beetles, European corn borers, boll weevils, and grasshoppers; DDT aerial sprays over forests fight such insects as the Douglas fir tussock moth, spruce budworm, and gypsy moth (see page 379).

Power equipment is of five types: high-pressure sprayers, low-pressure sprayers, mist blowers, dusters, and fog applicators. The power source is usually a gasoline engine, ranging from 1 hp in small machines to 75 hp or more in the larger machines. This sprayer (bottom) is blowing insecticides on orange trees. The air blast is produced by a modified airplane propeller that rotates at high speed.

the Century Mark

ASSOCIATION AFFAIRS

Pullman Meeting of the Pacific Division

The Pacific Division of the American Association for the Advancement of Science held its 35th annual meeting, 21–26 June 1954, on the campus of the State College of Washington at Pullman. Seventeen societies participated in a program of 315 scientific papers. Arrangements for the meeting were ably handled by a local committee and various subcommittees, under the general chairmanship of Adolph Hecht.

This was the second Pullman meeting of the Pacific Division, the first having been held in 1932. Persons who had the pleasure of attending both of these meetings, a little more than two decades apart, were greatly impressed with the growth of the State College of Washington, the expansion of its physical plant, and the continuous improvement of its facilities for both teaching and research.

Registration headquarters were in the Wilson Compton Union Building, an impressive and commodious student union building that was recently completed, with a cafeteria, dining rooms of assorted sizes for large and small groups, residence quarters where a number of delegates were housed, and ballrooms that can be used for social gatherings in the evening and can be divided during the day by movable partitions to serve as meeting places for smaller gatherings. Many of the scientific sessions were held here, while others were held in adjacent academic buildings.

Exhibits of scientific books and instruments were set up in a room immediately adjacent to the registration desk. A press room was provided in the Compton Union Building, and this facilitated good press coverage of the meeting. Tape recordings were made of a number of the programs of general interest; these were subsequently broadcast over the radio station operated by the State College of Washington.

The general sessions of the Pacific Division included two evening addresses and the annual meeting of the divisional council. On Tuesday evening, 22 June, A. H. Sturtevant, president of the Pacific Division, gave a thought-provoking address on "Social implications of the genetics of man" [*Science* **120,** 405 (10 Sept. 1954)]. On Wednesday evening, Alfred S. Romer addressed the Division on "Redbeds fossils and vertebrate evolution," dealing especially with the transition from aquatic to terrestrial life and the evolution of heat-regulating mechanisms.

The meeting of the council of the Pacific Division on Wednesday afternoon was addressed informally by G. W. Beadle, president-elect of the AAAS, and by Raymond L. Taylor, associate administrative secretary.

The council voted unanimously to elect the American Society of Agronomy, Western Branch, an affiliated society of the Pacific Division. This organization, which has not previously met with the Pacific Division, participated in the Pullman meeting with a large and very successful program.

Robert B. Brode of the University of California at Berkeley was elected president-elect of the Pacific Division. The president of the division for the coming year is Edwin R. Guthrie of the University of Washington. A. H. Sturtevant of the California Institute of Technology, the retiring president, became chairman of the executive committee.

Adolph Hecht of the State College of Washington was elected a member of the executive committee. H. Bowman Hawkes of the University of Utah and B. H. McConnaughey of the University of Oregon were elected members-at-large of the council.

The council learned with deep regret of the death on 21 June 1954 of Hermann A. Spoehr, a past president of the Pacific Division. A resolution of tribute to Dr. Spoehr was adopted and spread upon the minutes.

The following societies participated in the Pullman meeting:

American Meteorological Society
American Nature Study Society
American Society of Agronomy
American Society for Horticultural Science
American Society of Ichthyologists and Herpetologists
American Society of Limnology and Oceanography
American Society of Plant Physiologists
Association of Pacific Coast Geographers
Botanical Society of America
Cooper Ornithological Society
Ecological Society of America
Nature Conservancy
Northwest Scientific Association
Pacific Northwest Bird and Mammal Society
Society of Systematic Zoology
Western Society of Naturalists
Western Society of Soil Science

A number of very pleasant social events were arranged by the local committee. On Monday afternoon delegates and their wives were welcomed by President C. Clement French of the State College of Washington, and Mrs. French, at an informal

Table 1. Geographic distribution of registrants*.

Arizona	9	Massachusetts	3	Pennsylvania	1
California	*208*	Minnesota	1	South Carolina	1
Colorado	11	Missouri	1	South Dakota	1
District of Columbia	2	*Montana*	*21*	Tennessee	1
Idaho	*53*	*Nevada*	*3*	Texas	3
Illinois	1	New Mexico	5	*Utah*	*44*
Indiana	1	New York	5	Virginia	2
Kansas	2	North Dakota	1	*Washington*	*271*
Maryland	3	Ohio	4	Wisconsin	2
		Oregon	*101*	Wyoming	6
				Total, continental United States	767
Canada		Saskatchewan	4	India	1
Alberta	10	Brazil	2	Mexico	1
British Columbia	*21*	Egypt	1	Pakistan	1
Manitoba	1	*Hawaii*	*3*	South Australia	1
				Total, foreign or overseas	46
				Grand total	813

* Italic type indicates the seven states, the territory of Hawaii, and the Canadian province of British Columbia that comprise the Pacific Division of the AAAS. Their combined registration was 725, or 89 percent of the total.

reception. On Tuesday evening, following Dr. Sturtevant's address, there was a general reception in the Compton Union Building, sponsored by the State College of Washington chapter of Sigma Xi. On Wednesday evening a general smoker and social hour followed Dr. Romer's address. Thursday evening dinner was an outdoor barbecue for all persons attending the meeting. There were numerous activities for wives of delegates, including tours to points of interest, and recreation facilities, such as golf and swimming.

The total registered attendance at the meeting was 813 drawn from a wide geographic area, as shown in Table 1. Although predominantly a divisional meeting, as usual all sections of the United States were represented. The attendance from four Canadian provinces was particularly gratifying. There were registrants from six foreign countries, principally exchange professors or students in American universities. Twenty-eight localities in the state of Washington were represented.

The next meeting of the Pacific Division will be held at the California Institute of Technology, 20–25 June, 1955.

ROBERT C. MILLER, *Secretary*
Pacific Division, AAAS
California Academy of Sciences, San Francisco

Paying for the New AAAS Headquarters

A model of the new headquarters building which the Association plans to erect in 1955 was pictured in the October issue of *The Scientific Monthly*. Since then the board of directors has approved a number of more detailed aspects of the building program, has authorized the negotiation of a building contract, and has decided to ask the Association's members and friends for help in paying for the new building.

The AAAS is in the fortunate position of already owning the land and of having enough money (chiefly from economical operation in the past) to pay most of the cost of the new building. But we cannot pay all of it out of cash on hand. About $250,000 more than we now have and can safely invest in a building is needed to cover the total cost.

The Association is a good financial risk and could obtain a mortgage without difficulty. But the board hopes to avoid the necessity of jeopardizing other important activities by obligating future earnings and so decided to invite contributions to the Association's building fund.

The building plan has been slowly and carefully formulated. Some 10 years ago it became evident that we could no longer remain in the crowded Smithsonian Institution, which had generously housed the Association for 25 years. Further growth and future demands could be foreseen with sufficient clarity to make it seem desirable to plan a permanent headquarters building. The plan was supported by the Association's members and friends, whose generous contributions made it possible to take the first step of buying a desirable site. The block purchased included several old residences, one of which we have occupied since 1946, and which we have now outgrown. The second step was consideration by the board and council—consideration extending over several years—of the size and character of the building to be erected. With the approval of the council, the board has in the past year been making final decisions. Now we are ready to start construction on the permanent headquarters for which planning began nearly 10 years ago.

With construction about to begin, the Association will soon again ask for contributions to its building fund. As in 1945, there will be no quotas, visiting committees, or other high-pressure tactics. Before this year ends we will write individually to the Association's members and friends to invite them to help in the construction of the permanent headquarters of their Association.

Administrative Secretary DAEL WOLFLE

Special Events at the Berkeley Meeting

AAAS Special Sessions

One of the characteristic and most important features of the annual meeting of the Association is the series of outstanding addresses by distinguished persons, sponsored by organizations that meet regularly with the AAAS. These special events are joint sessions with the Association and are open to the general public of the city in which the meeting is held.

1) Monday, 27 Dec., 8:30 P.M., 155 Dwinelle; *United Chapters of Phi Beta Kappa*: "Our splintered learning and the status of scientists" by Conway Zirkle, professor of botany, University of Pennsylvania, Philadelphia. Peter H. Odegard, chairman, Department of Political Science, University of California, Berkeley, and member of the Senate of the United Chapters of Phi Beta Kappa, will preside.

2) Monday, 27 Dec., 8:30 P.M., Berkeley High School Audjtorium; *National Geographic Society*: "Five-star Burma" (illustrated) by W. Robert Moore, chief, foreign editorial staff, National Geographic Society. Wallace W. Atwood, Jr., director, Office of International Relations, National Academy of Sciences–National Research Council, Washington, D. C., and vice president for AAAS Section E, will preside.

3) Tuesday, 28 Dec., 8 P.M., Wheeler Auditorium; *AAAS Presidential Address*: "A half-century of quantum physics" by Edward U. Condon, director of research, Corning Glass Works, and retiring president of the Association. Warren Weaver, director, Division of Natural Sciences and Agriculture, Rockefeller Foundation, and president of the Association, will preside. Preceding the address, Robert Gordon Sproul, president, University of California, and general chairman of the Berkeley meeting, will speak briefly. Following the address there will be an informal AAAS Presidential Reception in the nearby Stephens Union Clubrooms.

4) Wednesday, 29 Dec., 8 P.M., Wheeler Auditorium; *Society of the Sigma Xi*: "High-energy physics" by Edwin M. McMillan, professor of physics, University of California. Joseph W. Barker, director, Research Corporation, and acting president, the Society of the Sigma Xi, will preside.

5) Thursday, 30 Dec., 4 P.M., Wheeler Auditorium; *Pacific Science Board:* "The human background of Pacific science" by Alexander Spoehr, director, Bernice P. Bishop Museum, Honolulu. Knowles A. Ryerson, dean, College of Agriculture, University of California, Berkeley, and past chairman, Pacific Science Board, will preside.

6) Thursday, 30 Dec., 8 P.M., Wheeler Auditorium; *Scientific Research Society of America*: "Science and progress?" by Vannevar Bush, president, Carnegie Institution of Washington. Joseph W. Barker, director, Research Corporation, and chairman, the Scientific Research Society of America, will preside.

AAAS Symposiums

Well-established scientists and younger specialists alike anticipate the AAAS symposiums which have become an increasingly important aspect of the annual meetings of the Association.

AAAS symposiums explore relatively neglected areas of scientific inquiry or constitute up-to-date surveys of knowledge in particular fields. Such programs are significant and valuable because they focus attention on critical areas, summarize the present status of current research, and provide positions from which to direct further research. These programs originate in the minds of the officers and committeemen of the 18 sections of the Association and are developed by them, either personally or by others deputized as program chairmen. Often, the sectional symposiums are concerned with interdisciplinary problems and are sponsored by two or more sections; participating societies also may collaborate. If the demand warrants it, the papers of such programs are gathered together and published by the Association as symposium volumes.

In recent years there has become well established the practice of arranging, for each annual meeting, one or two symposiums of especially wide interest or timeliness. The responsibility for developing these general symposiums sponsored by the Association as a whole, rests upon the AAAS Symposium Committee, appointed each year by the president of the Association. Upon occasion, a proposed sectional program may be chosen to be developed as a general symposium; more commonly, the Symposium Committee, which represents a variety of scientific fields, plans and arranges these general sessions itself. The committee may seek the aid of consultants and appoint others to implement the general symposiums.

The Symposium Committee met in February and decided on one three-session general symposium that would give broad consideration to some of the principal problems confronting society today and their interrelations with science.

AAAS General Symposium

Science and society, part I, "Natural resources: power, metals, food." Monday, 27 Dec., 4 P.M., Wheeler Auditorium. Arranged by Louis B. Slichter, director, Institute of Geophysics, University of California, Los Angeles. Donald H. McLaughlin, president, Homestake Mining Company, San Francisco, will preside. (i) "Fuels and energy for the future" by Farrington Daniels, chairman, Department of Chemistry, University of Wisconsin; (ii) "Minerals for the future" by Evan Just, vice president, Cyprus Mines Corporation, New York; (iii) "Food for the future" by J. G. Harrar, deputy director for agriculture, Division of Natural Sciences and Agriculture, The Rockefeller Foundation, New York.

Science and society, part II, "Population problems." Tuesday, 28 Dec., 4 P.M., Wheeler Auditorium. Arranged by Curt Stern, professor of zoology, University of California, Berkeley. Curt Stern will preside. (i) "Introduction" by Curt Stern; (ii) "Dynamics of human populations" by Dudley Kirk, Population Council, New York; (iii) "Medical aspects" by Alan Gregg, vice presi-

dent, Rockefeller Foundation, Big Sur, California; (iv) "Concluding remarks" by Curt Stern.

Science and society, part III, "Science in human thought and action." Wednesday, 29 Dec., 4 P.M., Wheeler Auditorium. Arranged by Roger R. Revelle, director, Scripps Institution of Oceanography, La Jolla, California. Roger R. Revelle will preside. (i) "The role of the sciences in education" by Joel H. Hildebrand, emeritus professor of chemistry and chemical engineering, University of California, Berkeley; (ii) "Science and international cooperation" by Bart J. Bok, professor of astronomy, Harvard University, Cambridge, Massachusetts; (iii) "Logics and the human nervous system" by John von Neumann, Institute for Advanced Study, Princeton, New Jersey.

AAAS Conferences

In recent years, in addition to the Academy Conference, several conferences have become recurrent events at AAAS meetings. Also, interest in special subjects may develop to the point where a special program is arranged. These conferences and special programs are open to all who are interested.

1) *Academy Conference.* Two sessions: Monday morning and afternoon, 27 Dec., 33 Dwinelle.

2) *Conference on Scientific Editorial Problems.* Four sessions: Wednesday morning, afternoon, and evening, and Thursday afternoon. 29 and 30 Dec., 125 Hilgard.

3) *Conference on Scientific Manpower.* Two sessions: Tuesday and Wednesday mornings, 28 and 29 Dec., 104 Engineering.

4) *International Conference on Animal Venoms,* sponsored by AAAS Sections F and N. Eight sessions: 4 days, 27–30 Dec., 155 Dwinelle.

5) *Third Berkeley Symposium on Mathematical Statistics and Probability,* arranged by the Statistical Laboratory of the University of California. Ten sessions: 5 days, 27–31 Dec.

AAAS Special Program

The Association, its Cooperative Committee on the Teaching of Science and Mathematics, the Academy Conference, the Engineering Manpower Commission, and the Scientific Manpower Commission are cosponsoring an all-day session, planned as a forum to discuss and to launch an action program to attempt to meet the acute problem of the shortage of qualified science teachers. The morning session will be directed to research scientists; the afternoon, to those interested in the recruiting and training of teachers.

The crisis in science education, part I, Thursday, 30 Dec., 10 A.M., auditorium, Chemistry Building. John R. Mayor, chairman of the Cooperative Committee and chairman of the Department of Education, University of Wisconsin, will preside. (i) "The scientist's responsibility to the science teacher" by George W. Beadle, president elect of the AAAS and head of the Department of Biology, California Institute of Technology; (ii) "The educator's responsibility to the science teacher" by Samuel Brownell, U.S. Commissioner of Education.

The crisis in science education, part II, Thursday, 30 Dec., 2 P.M., auditorium, Chemistry Building. Dael Wolfle, administrative secretary, AAAS, will preside. (i) "The AAAS program to improve science teaching" by Dael Wolfle; (ii) "The program from the point of view of the high school" by Wayne Taylor, Denton (Texas) High School; (iii) "The program from the point of view of the college of education" by William A. Brownell, dean, College of Education, University of California, Berkeley; (iv) "The program from the point of view of the graduate school" by Vern O. Knudsen, dean, Graduate School, University of California, Los Angeles; (v) "The program from the point of view of the liberal arts college" by E. Wilson Lyon, president, Pomona College.

RAYMOND L. TAYLOR
Associate Administrative Secretary

New AAAS Sections

The number of AAAS sections has increased from 16 to 18 as a result of Council approval of the elevation of former Section N Subsections Nd-Dentistry and Np-Pharmacy to full sectional status. (Former Subsection Nm-Medicine will now be identical with Section N-Medical Sciences.)

For some years the Sections on Dentistry and Pharmacy have had their own secretaries and arranged separate full programs at the annual meetings of the Association. Henceforth, with their own vice presidents and section committees, they may enlarge their activities and function as sections in their own right.

Increasing sentiment among Nd and Np members favoring sectional status crystallized at the Boston meeting, and petitions were directed to the Section N Committee which approved. Subsequently, the AAAS Board of Directors endorsed this action and approval by the AAAS Council was granted by a mail ballot. The former secretaries of the subsections—Russell W. Bunting, dean, School of Dentistry, University of Michigan, and Glenn L. Jenkins, dean, School of Pharmacy, Purdue University—will continue as sectional secretaries, and complete sectional organization will be concluded at the Berkeley meeting.

The following affiliated and associated societies have been transferred to the new sections:

Nd-Dentistry

Affiliated Societies: American College of Dentists; American Dental Association; International Association for Dental Research, American Division. *Associated Society*: American Association of Dental Schools.

Np-Pharmacy

Affiliated Societies: American College of Apothecaries; American Pharmaceutical Association. *Associated Societies*: American Association of Colleges of Pharmacy; American Society of Hospital Pharmacists.

LETTERS

Sources of Apparent Animism in Students

Largely because students said various objects were living, Dennis (*1*) and Crannell (*2*) concluded that many of them are animistic.

Animism may be defined as attributing to nonliving objects some characteristic(s) peculiar to plants and animals. Does labeling an object "living" constitute a dependable sign of animism? Certainly such labels can arise from animism, but they also can arise from other conditions. This paper reports a repetition of one of Dennis' experiments with certain questions added to illuminate the underlying causes of labelings that, taken at face value, appear to be animistic.

Dennis' instructions (*1*, p. 248) were read to 155 students (*3*) who then wrote whether various objects were living (items 1–8 in my Table 1), and whether the sea knows the location of ships (item 9), a pearl feels the water moving (item 10), the ocean feels the pull of the moon (item 11). For each item, the students wrote their reasons for answering as they did. The new questions were these: (12) List any difficulties you experienced in answering these questions. (13) Did you answer the questions seriously and to the best of your knowledge? (14) Have you participated in this experiment before or discussed it with anyone? (None had.) (15) Define what you mean by *living*.

The percentage of students who labeled objects "living" varied greatly from class to class, but it was lowest in the advanced philosophy and psychology courses. However, as in Dennis' study, a sizable minority in each class (23 to 66 percent) labeled at least one object as living. Why?

At least four explanations are available: (i) the students might have been joking or speaking whimsically or poetically; (ii) they might have had difficulty in reasoning; (iii) they might have made careless observations or had other faulty information concerning the objects; (iv) there may have been semantic confusions. Any of these could cause the students to label objects "living," either with or without accompanying animism.

The data do not fit the explanation that these labelings are whimsy or a joke. To question 12, 92% of the students listed difficulties at considerable length. The style of these replies also suggests that the questions were being considered seriously. For example, one "animistic" labeler wrote: "You have raised questions in my mind that I have never thought of before. How do you define living?" Another, "I need to have time to think about these in order to be able to give an intelligent reason for my answers. . . . I've never been asked questions of this sort before, so they came as rather a surprise." Of the "animistic" labelers, all but two wrote some such reply.

Also, 97 percent said they answered the questions "seriously and to the best of their knowledge." Their claim is supported further by the fact that after the experiment the students began animated discussions concerning definitions of life. In the psychology classes, these discussions continued for the remainder of the class period and were raised again at our next meeting. Seldom do students behave this way when they deem something silly. In light of these data, it seems extremely unlikely that the labels were a joke, or even a poetical outburst.

It also seems unlikely that animism was a major determinant of their replies. Even the students who labeled something "living" almost never endowed it with any characteristic peculiar to life in the biologist's sense. For example, 23 percent labeled a lighted match as "living." Their reasons follow: has molecules, or flame, in motion, 5 percent; undergoes changes, 5 percent; uses oxygen, 3 percent; is affected by the environment, 2 percent; gives light and/or heat, 3 percent; produces something, affects living things, or fulfills its purpose, 3 percent; is as alive as a match can be—is functioning, 1 percent; flame grows and dies out, 1 percent; was living until burned out, 1 percent. Only the last two of these, in my judgment, evince animism. Although 23 percent of the students labeled a match "living," only 2 percent apparently attributed to it any characteristic peculiar to plants and animals. Similarly, most of the students who said the other objects were living did not show any overt animism. Altogether 43 percent labeled one or more objects as living, only 8 percent endowed any object with a characteristic peculiar to plants and/or animals.

Rather than stemming from animism, the label of "living" seems to arise mainly from other mistakes in reasoning and from semantic difficulties.

In their definitions of life 90 percent of the "animistic" labelers did not include (i) the capacity for reproduction, (ii) metabolism, or (iii) both. When these students label something "living," they obviously do not mean what biologists do. Obviously also, with

Table 1. Animism in 155 college students (percentages).

Item	Object	Labeled "living"	Gave an animistic reason
1)	Unlighted match	8	
2)	Lighted match	23	3
3)	Electric clock	12	2
4)	The sun	39	8
5)	The wind	18	6
6)	Gasoline	12	
7)	Clouds	19	5
8)	The ocean	25	4
9)	Sea knows?	10	2
10)	Pearl feels?	9	8*
11)	Ocean feels?	10	

* All of these students said that the pearl was part of the living oyster.

such a definition students can label inorganic things as "living" with no underlying animism.

Living is a highly ambiguous term. We speak of living ideas, a living language, or a living religion, using the term to denote the quality of being extant and used by people. Many "animistic" labelers defined *living* this way—as simply "existing," or "being real," or "having a function useful to man." Geologists speak of living and dead glaciers. Physicists refer to live electric circuits. Almost all the students who said the electric clock was living said "because electricity is flowing through it"—using *live* in the physicists' sense. Under none of these definitions does *living* imply possession of any property peculiar to plants and animals.

Semantic confusion also surrounds *ocean*. Half of the students who said the ocean is living, or can feel the tides, wrote comments such as this: "What do you mean by ocean? I intend it to include the creatures in the water." With this definition of ocean, their reply that the ocean is living or has feeling should not be construed as animistic. Here again, few "animistic" labelers appear to be animistic.

Confusion in the denotation of words is more extensive than the foregoing considerations imply. The students shifted their implied definitions from one item to the next, sometimes using a word one way and sometimes another. Such disorder generally results, of course, when the same word has several meanings.

Their reasoning also is confused. About two-thirds of those who classified something as living gave reasons that did not logically fit with their own formal definition of life. They made other mistakes too. For example, more than one-third of those who said that the sun or the ocean is living said "because it is essential to life." (Two students explicitly added that the sun is not living in the same sense we are.)

Their most common error in logic involved the assumption that if some attribute is often found in living organisms, possession of that attribute is sufficient for classifying the possessor as living. They seem to confuse *if* and *only if*. The reasons they gave most frequently for calling things alive were that it has some use, shows movement (no explicit distinction being made usually between *can move* and *can be moved*), is affected by the environment, sustains life, undergoes chemical changes. Although common characteristics of plants and animals, these are not their distinguishing marks. Many apples are red; therefore, anything red probably should be called an apple. This is the line of reasoning these students often followed.

This mistake is made by both animistic and nonanimistic thinkers. The two groups differ in that animistic thinkers draw a further faulty conclusion: if an entity has some characteristic possessed by plants and animals, it not only should be labeled "living" but also probably has many other characteristics possessed by plants and animals, including some characteristics peculiar to them. To nonanimistic thinkers, on the other hand, the label "living" indicates possession of some characteristic common among other "live" things but not characteristics peculiar to plants and animals (*4*). Apparently most of our students who labeled objects as "living" belong to this latter class. As their definitions of *living* and their reasons for their labels clearly show, few of them construe *living* as necessarily implying possession of properties of growth, of ability to move independently, of reproduction, of feeling or thought or motives, any other characteristic whatsoever peculiar to life in the biologists' sense. Although confused, few students in this experiment appear to be animistic.

Active animism probably could be engendered in them easily, however, for they are rather inept thinkers, and even skilled thinkers are prone to believe that things with the same label *must* have much in common.

VIRGINIA VOEKS

Department of Psychology and Philosophy,
San Diego State College

References and Notes

1. W. Dennis, *Sci. Monthly* **76**, 247 (1953).
2. C. W. Crannell, *ibid.*, **77**, 54 (1954).
3. Allan Shields and William McBlair helped design the experiment and collected the data from classes in Introductory Philosophy (26 students), History of Philosophy (24), and General Biology (41). The other students were in Social Psychology (34) and Developmental Psychology (30).
4. This would be a mistake, logically, except for the fact that *living* does have accepted meanings in addition to the one given it by the biologists.

The "First" Hyatt-Shaler-Verrill Expedition

Ralph W. Dexter's article, "Three young naturalists afield: the first expedition of Hyatt, Shaler, and Verrill" [*Sci. Monthly* **79**, 45, (July 1954)], conveys several erroneous impressions. In the first place it was not, as the title indicates, the first expedition of the trio. A year earlier, in July of 1860, the three naturalists spent about 3 weeks on an expedition to Mount Desert Island, Maine. It was, in a sense, a rehearsal for the Anticosti trip, since they indulged in hiking on the island, collecting, exploring the beaches, and dredging offshore. Shaler in his *Autobiography* [Houghton Mifflin, pp. 133–135] briefly describes the affair while a detailed account is given in Addison E. Verrill, *Diary, 1860–64* [manuscript, Harvard University Archives].

Nor was the trip first planned in January 1861, as is implied in Hyatt's journal. Verrill's *Diary* reveals that the trip was discussed by the three at least as early as 9 December 1860 when the trio was ice skating. As for the expedition itself, it should be noted that Verrill has left a very complete account in another of his diaries, *Diary of Anticosti Expedition, 1861* [manuscript, Harvard University Archives].

Dexter's conclusion that "this field experience certainly instilled the belief of organic evolution into the thinking of these three young men" also needs examination, for there is good reason to believe that the three accepted Darwinism some time before the Anticosti expedition. In the first half of 1860 the three naturalists were subjected to the debates on Darwinism between Louis Agassiz, Asa Gray, and William Rogers before the Boston Society of Natural History, and this

experience appears to have been most important in helping them to make up their minds in favor of Darwinism. The difficulty was that, being students of Agassiz, open acceptance of Darwinism was dangerous. As Shaler recalled, ". . . in those primitive days when the students in the [Lawrence] Scientific School were members of warring camps . . . it was dangerous for a student to be seen in parley with the enemy, and the leaders were not supposed to have much to do with the adversary's recruits."

WALTER L. BERG
History Department, University of Washington

Walter Berg's criticisms are both interesting and deserving of further discussion. If I have given "several erroneous impressions" I am sorry and hope that his letter will correct them for the readers of *The Scientific Monthly*. However, I should like to comment on the points that he has raised.

My title, in view of the earlier field trip to Maine, is not strictly accurate, but the Anticosti expedition of 1861 was the first *major* one for the trio that could be called a full-fledged expedition devoted to original research. If the three young men had discussed their plans for this expedition to Anticosti earlier than the account given by Hyatt, he must have forgotten about it, since his diary as published in my article tells when he was first brought into the plans according to his own interpretation.

In pursuing my study I did not learn of the Verrill diary deposited in the Harvard University Archives until after my final draft had been completed. One of Verrill's sons, with whom I corresponded, did not know what had become of his father's Anticosti diary. Later, I learned from the widow of another son that the manuscript had been given to Harvard. By that time I felt it would contain little that would change my paper materially, since I had no intention of reporting a complete account (I used only a selected portion of Hyatt's diary), but was more interested in presenting the highlights of the expedition which would give the reader a concept of the trials and tribulations, as well as the accomplishments, of three young undergraduates pursuing their absorbing interest in natural history. Doubtless Verrill's diary contains some details not given by Hyatt, but I question whether it contains any matters of significant difference. After all, they were "all in the same boat," to use a colloquial expression which I think is very apt here.

In his final point of criticism, Berg has tried to make too much of my statement regarding the significance of the expedition. I did not claim that the acceptance of Darwinism by the three young men began precisely at the time of their return from Anticosti. I simply said, and meant by my brief remark, that their own field study made clear to them that the teachings of the evolutionary school of thought were more in line with their own experience than were the antievolutionary ideas expounded by Cuvier and Agassiz. The young men became staunch supporters of the evolutionary theory in their teaching careers. The later works of Hyatt, especially, were inspired by the Darwinian theory, and many of his researches were an outgrowth from his early observations and collections of fossils on Anticosti.

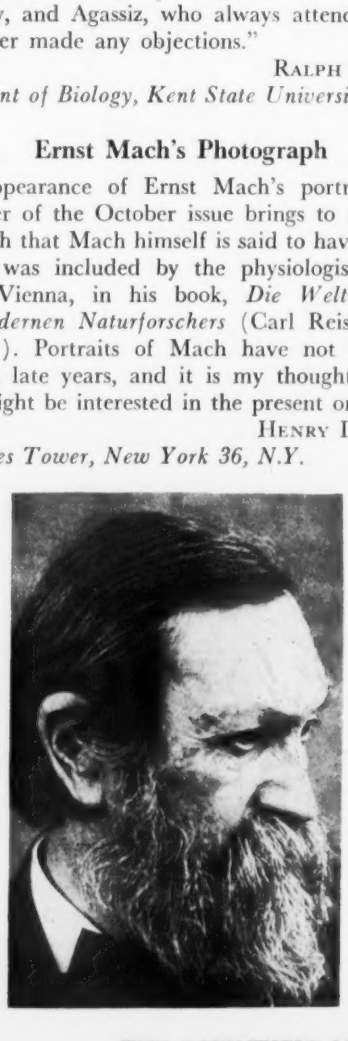
The real difference between Berg's interpretations and mine are fundamentally based on the fact that we are looking at the same events through the eyes of different persons. My study was stated specifically to be based upon the diary of Hyatt, which I reported faithfully. Berg has chosen to view the events as seen by the other two men. Such varying points of view can be well illustrated by Berg's own statement based upon the account of Shaler that, "being students of Agassiz, open acceptance of Darwinism was dangerous." Undoubtedly this must have been generally true, but, to show how another person reacted to this same matter, let me quote from the *Biographical Memoir of A. S. Packard* [Cockerell, Natl. Acad. Sci. U.S. Biog. Mem. **9**, 197 (1920)]. Packard, a contemporary of Hyatt, Shaler, and Verrill, also studied under Agassiz and taught under him at the famous Anderson School of Natural History in 1873. Cockerell wrote, "Packard, in lecturing at Penikese, expressed his evolutionary views most fully, and Agassiz, who always attended his lectures, never made any objections."

RALPH W. DEXTER
Department of Biology, Kent State University

Ernst Mach's Photograph

The appearance of Ernst Mach's portrait on the front cover of the October issue brings to my mind a photograph that Mach himself is said to have liked best and that was included by the physiologist, Theodor Beer of Vienna, in his book, *Die Weltanschauung Eines Modernen Naturforschers* (Carl Reissner, Dresden, 1903). Portraits of Mach have not often been printed in late years, and it is my thought that your readers might be interested in the present one.

HENRY I. WACHTEL
1001 Times Tower, New York 36, N.Y.



BOOK REVIEWS

Name Reactions in Organic Chemistry. Alexander R. Surrey. Academic Press, New York, 1954. viii + 192 pp. $4.

IT is rare to find a short book in chemistry that contains clear, concise, and accurate data that at the same time may be considered comprehensive in its treatment of the subject under consideration. Surrey's book has succeeded in this unusual task and may be considered a baby, one-volume edition of the "Organic Reaction" series. The author has briefly summarized the principal reactions for more than 100 name reactions, of which only about 40 have heretofore been treated in the "Organic Reaction" series. Eventually the series will give comprehensive and detailed material on the other 60 reactions, and until that time this book fills in nicely.

The choice of name reactions covers the whole field of organic chemistry, and the main types are selected in order to give the maximum amount of information for the field. Reaction mechanisms are used wherever possible, and the treatment combines classic synthetic organic chemistry with modern concepts in an authoritative and readable manner. Each name reaction is described and illustrated, and the side reactions are discussed. If rearrangements may take place under slightly different conditions, they are also described. References follow each name reaction, so that it is easy to go immediately to the literature for the reaction under consideration. This saves time for the chemist.

An interesting feature of Surrey's book is the historical section, which consists of two or more paragraphs devoted to the main points in the life of each person, his important contributions, and the fields in which he worked. I feel that too little attention is given to the history of chemists, the background under which they worked, and the interlocking of various contributions. An attempt is made to bring out these points, and I believe that most chemists will read the historical section first unless they are particularly rushed. Some background material will also aid in linking the reaction to the name given to the reaction.

The synthetic organic chemists will find this book more useful than those in other fields. And for a quick, handy reference before going to the "Organic Reactions" series, I know of no other book that fulfills this purpose as well.

The subject index (14 pages) is very complete and has been carefully compiled. It has been set up as a preparation index that leads immediately to the reaction mechanism postulated (proved in many cases) and to a quick summary of the topic. The author is to be congratulated on this little volume. Similar work in other fields would be welcome.

THOMAS S. GARDNER

Hoffman-La Roche, Inc.

Aerodynamics. Selected topics in the light of their historical development, Theodore von Kármán. Cornell Univ. Press, Ithaca, N. Y., 1954. ix + 203 pp. Illus. $4.75.

ALMOST any reader should be able to obtain an unusual combination of information and enjoyment from *Aerodynamics.* Von Kármán's purpose is to present to the reader who is unacquainted with aerodynamic theory a picture of our present concept of those scientific and engineering principles to which he has contributed so much. At the same time, he would like to impress even his aerodynamicist reader with the large amount of mental effort that was needed to come to our present understanding but can now be acquired in so small a fraction of the time by a student.

Throughout his story of the development of the theory of lift, drag, skin friction, turbulence, compressibility, shock waves, airplane stability, rocket engines, and even space flight, he always leaves one with a clear physical picture of what we know about these subjects today. He uses almost no mathematics, but he often appeals to the reader's knowledge of mechanics and thermodynamics or to his mathematical judgment.

Since it is largely written in the first person, almost anyone interested in aviation will find it delightful reading. One sees the frightened von Kármán trying to discuss high-speed aerodynamics while rushing down the narrow English lanes with Lanchester behind the wheel, the humorous incidents that led to the publication of the famous paper on the Kármán vortex street, and his account of the discussion with Hugh Dryden which resulted in the invention of the word *transonic* (Dryden still insists that it was he that held out for the single *s*). Through von Kármán's acquaintance, the reader meets such figures as Prandtl, G. I. Taylor, Eiffel, Kettering, Howarth, Kolmogoroff, and von Braun. He even takes a ride on Flettner's rotor ship as he sees the part that it played in man's struggle to understand how airfoils produce lift.

MILTON U. CLAUSER

School of Aeronautics, Purdue University

The Power of Words. Stuart Chase in collaboration with Marian Tyler Chase. Harcourt, Brace, New York, 1954. 308 + xii pp. $3.95.

THE scientific study of human communication and of the relevant processes of symbolization is quite new. The knowledge to be gained from it should make a difference between the past and the future of mankind. This book suggests that the difference might possibly be something like that between the first 9 days of a kitten's life and the rest of its mortal career.

The Chases show how vast and intricate the in-

vestigation of language and its functions must be and how essential to it, therefore, is teamwork among many different kinds of specialists. They sketch the contributions to communication research and theory of "brain physiology, cybernetics, the psychology of perception, animal psychology, child psychology, the culture concept, linguistics, metalinguistics, the languages of science, semantics, general semantics, group analysis." The authors present as main conclusions to date that structured language, evaluative in function, is distinctively human; that an understanding of the symbolization function is essential to an understanding of the human nervous system, and vice versa; that language is man's basic means of survival; that it is essential to, and generally conducive to, cooperation and group stability; that through language men create culture; that linguistic and semantic, and therefore cultural, relativity is a basic fact; and that communication is subject to significant improvement, now that it is being subjected to scientific scrutiny and manipulation.

The authors show some of the practical differences this knowledge makes when applied by writers, economists, politicians, doctors, and teachers. They operate with the new semantic tools, as they call them, on congressional investigators and the communists they investigate, on gobbledygook, and on the problems of the mass media.

The Chases have made an honest, competent summary of an amount of material that few readers, scientists included, could ever cover otherwise. By doing this, they have made it easier for each specialist in the communications research team to know and work effectively with his teammates. At the same time, the authors have made it possible for the general public to be informed much better than ever before of developments that affect the lives of all men in new and crucial ways. Not least important, they have demonstrated that a readable book, produced by writers who are semantically trained, can be on the whole dependable as well as clear, important as well as simple.

WENDELL JOHNSON
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Vegetable and Flower Seed Production. Leslie R. Hawthorn and Leonard H. Pollard. Blakiston, New York, 1954. xiii + 626 pp. Illus. $7.50.

ANY person concerned directly or indirectly with any phase of horticulture or olericulture has a need for this book—a book packed with documented and up-to-date information on the production, storage, and merchandising of vegetable and flower seeds.

The contents are divided formally into four parts: Part I, "The vegetable- and flower-seed industry," introduces the subject, establishes its scope, and points out the significance of environmental factors in seed production and the dominant role of plant breeding in the industry; Part II, "Vegetable seed crops," occupies the bulk of the book and is a detailed presentation of the situation for each of 10 major families or groups of vegetables such as the Umbelliferæ (carrots, celery, and so forth.), Liliaceæ (onions, asparagus), Compositæ (lettuce, endive, chicory), Cucurbitaceæ (such as melons and squash), Gramineæ (sweet corn), Leguminosæ (peas, beans), Cruciferæ (cabbage, cauliflower, broccoli, mustard, turnip, radish), Chenopodiaceæ (beet, spinach, chard), Solanaceæ (tomato, pepper, eggplant), and miscellaneous vegetables (rhubarb, okra, New Zealand spinach); Part III, "Flower seed crops," occupies about 10 percent of the book and treats the production of seed of annuals separate from that of perennials and biennials; and Part IV, "Handling of matured crop," covers the types and operation of harvesting and milling equipment, instructions on the storage and transportation of seed, and technical considerations relative to seed-growing contracts, seed certification, seed processing for market, and regulations governing the seed business.

The introduction of the subject contains a good, if too brief, historical review of the development and rise of seed houses in America from that founded by David Landreth at Philadelphia (1784) to that by Joseph Breck at Boston (1818), by J. M. McCullough at Cincinnati (1838), by Thomas Griswold at Wethersfield, Conn. (1845), and John Bodger at Santa Paula, Calif. (1891).

The dependence of the modern seedsman on the professionally trained plant breeder is not only emphasized throughout, but details of breeding techniques and origins are given for a substantial number of crops. For each crop accounted in Part II there is provided a section on economic importance of the seed crop, areas of seed production, characteristics of the plant (with emphasis on reproductive parts, the fruit and seed), cultural methods for growing the plants for seed production, breeding techniques, harvesting and milling the seed, and usually an excellent summary on insect and disease control.

The book is valuable, not only for its collation and synthesis of a vast amount of material, but equally so, to the vegetable specialist, for its excellent bibliographies that terminate each of the 21 chapters. A cursory count shows an excess of 750 titles to be included. These cover many papers on related topics of general culture, as well as those more pertinent to seed production. In these citations to the literature (45 percent are of the references published since 1945 and about 30 percent to those published during 1935–45), one possesses references to a majority of the pertinent books and articles dealing with the vegetable growing industry.

The authors are specialists in vegetable research. It is clear that the wide backgrounds of these two men contributed materially to the excellence of this book. It is also a partial reason why its treatment of the flower seed industry is weak. A second and very valid reason for this apparent scant treatment is that much less has been published on the subject, and much less is known of the problems involved. The authors' unfamiliarity with the flower seed industry may also ac-

count for the greater number of typographical errors in the 60-odd pages of this section. Even so, the number is exceedingly low.

This book fills a need of long standing. It will be of use to a large number of persons and should enjoy a good export market. I hope that its publication will stimulate the preparation and publication of a companion volume for the lesser known but equally important field crops, cereals, and forage plants.

GEORGE H. M. LAWRENCE
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New Green World. Josephine Herbst. Hastings House, New York, 1954. 272 pp. + plates. $4.

JOSEPHINE HERBST tells in *New Green World* of the early American naturalists. This bright green world is long since gone along with the Bartrams, father and son, who are her principal characters, and all the ardent explorers of the botanical wonders of the new continent of Colonial times. The twin forces of greed and necessity, the latter ever growing with a surging population, have stripped the vegetation from a continent. The murmuring pines and the hemlocks have disappeared into pulpwood, and the most secluded dells and forest nooks are littered with the empty beer cans of a generation of thoughtless products of progress. Perhaps, indeed, this beautiful new green world, which the author describes in such a delightful manner, never quite existed in reality but only in the minds of Bartram, the Quaker with the exploring mind, Collinson, his English friend and agent, and all the gentle people who were driven by some inner force to attempt the rescue of the new plant marvels of a continent from the "common passion to get and to hold."

The author makes these men of 18th century England and America live again in the stage setting of a new and little known wilderness, a wilderness that extended for John Bartram from the northern lakes to Florida and westward into the Indian country. The description of their ambitions and of their impact on their times, of the great gardens of England and the more modest ones of the Colonies makes fascinating reading. The faith of the Bartrams in the great pattern of nature; their wonder at the mystery of the universe (whether manifest in the trees and rare flowering plants of swamp, meadow, and forest or in the birds, turtles, and insects); and their sureness of their place in the natural world are a lesson to the people of our over-complex troubled time.

There will always be those who find a feeling of justification, so important in our age of great machines and great social movements, in the simple art of gardening. They are the spiritual heirs of the Bartrams and their contemporaries. To them especially *New Green World* will present a delightful and provoking picture of the early American practitioners of the gentle art.

JOHN M. WINTER
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Pioneer Plant Geography. The phytogeographical researches of Sir Joseph Dalton Hooker. W. B. Turrill. vol. 4, *Lotsya: a Biological Miscellany.* Frans Verdoorn, Ed. Martinius Nijhoff, The Hague; Chronica Botanica, Waltham, Mass., 1953. x + 267 pp. Plates. Fl.19.

IN this book the general statements and observations about plant distribution that were made by Sir Joseph Dalton Hooker, which were often included in the prefaces to monographs or in small papers upon particular travels, have been gathered together to make what is essentially a posthumous "phytogeography." Although a patch-work job in some ways, the assembling has been done with skill and the book contains much that will be of interest to phytogeographers as well as to students of the history of botany. The compiler summarizes and appraises Hooker's contributions in the concluding chapters, but for the most part the book is in Hooker's words. Hooker's active life spanned virtually the entire Victorian period and his travels took him to many parts of the world that a single botanist can scarcely hope to see these days. For, despite our greatly improved transportation, we seem to travel less (it is more expensive, for one thing), or see less if we do travel more, than our leisurely forebearers who had to ride archaic trains and ships and do their botanizing afoot or from beasts of burden.

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Annual Review of Medicine, Windsor C. Cutting, Ed.; Henry W. Newman, Assoc. Ed. Annual Reviews, Stanford, Calif., vol. 5, 1954. ix + 490 pp. $7.

THE tempo of modern research is reminiscent of a much quoted thought from Lewis Carroll's *Alice in Wonderland*: "You've got to keep running to stay where you are." Of paramount significance is the fact that such comprehensive reviews, as one finds in *The Annual Reviews of Medicine,* volume 5, indeed help the individuals working in various parts of the world to remain in the photo-finish so that they may have the knowledge that is currently available.

Students of medicine, practicing physicians, teachers, and experimentalists in the basic and clinical sciences will find this volume of considerable importance. These reviews show a great deal of improvement over those found in previous volumes in this series. This is due in large part to the accrued maturity of this series which was parturiated only 5 years ago. The material covered is most abundant; the fields of medical knowledge included are quite diverse; the contributions can be truthfully regarded as growing pillars of information for the medical sciences, and this particular volume records the advances of medicine in a most exhaustive manner.

Volume 5 is divided into 20 sections, each of which covers a broad area of investigation such as: (i)

infectious diseases; problems of antimicrobial therapy; (ii) diseases of the gastrointestinal tract; (iii) diseases of the cardiovascular system; (iv) diseases of the kidney; (v) diseases of the reticuloendothelial system and hematology; (vi) endocrinology; (vii) allergy; (viii) neoplastic diseases; (ix) diseases of the nervous system; (x) psychiatry; (xi) diseases of the respiratory system; (xii) physical agents and trauma; (xiii) anesthesia; (xiv) radioactivity; (xv) laboratory aids to diagnosis and therapy; (xvi) toxicology; (xvii) dermatology; (xviii) pediatrics; (xix) dentistry; and (xx) annotated list of reviews in medicine.

Extremely special care has been taken not to duplicate certain areas of research that have been reviewed in the recent literature. Everywhere throughout this book, the author conserves valuable space by inviting attention to previously published reviews that come within the purview of his subject matter. This is certainly praiseworthy, and it establishes a precedent that should be adhered to throughout the scientific literature.

Critically evaluated, this volume will earn a great place in the hands of many communities of scholars where questions and answers related to the physiological laws and health of man are dealt with constantly.

JOSEPH T. VELARDO

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Peter Bent Brigham Hospital

Mammalian Germ Cells. Ciba Foundation Symposium. G. E. W. Wolstenholme, Ed. Little, Brown, Boston, 1953. 302 pp. Illus. + plates. $6.75.

THIS small volume consists of papers by 40 specialists in the physiology of reproduction from six countries, chiefly England and the U. S. The subject matter is approximately equally divided between spermatozoa and ova. Considerable attention is given to certain biochemical constituents of semen: ergothioneine and its importance because of the sulfhydryl group it contains; meso-inositol (Mann); amino acids and fructose in relation to androgen levels and fertility in cattle (Gassner); proteolytic enzymes (Lundquist); "quality" of semen in relation to fertility in man (MacLeod, P. M. F. Bishop, Ian Donald).

Three-dimensional movement of sperm was demonstrated by clever techniques of illumination by Lord Rothchild. Survival, with functional capacity of sperms after freezing in liquid air, and longevity of sperms at various *p*H's, were discussed by Polge and Kok, respectively. Van Demark described the remarkably rapid transit of sperms through the genital tracts of cows. Data on fertilizability of rabbit eggs, with reference to age of eggs and sperms, number of sperms (dilution), and constituents of seminal plasma that favor fertility were presented by Chang. Adams succeeded in raising rabbits from eggs secured from juvenile females artificially ovulated by gonadotroph; the experiment succeeded only when these eggs were transplanted into mature foster mothers. Venge reported (first authentic case?) the observed fertilization of rabbit eggs *in vitro*. Early death of embryos was demonstrated to be due either to inherently defective germ plasm (Hartman) or to demonstrable endocrine deficiencies (Casida).

In these pages the reader will find authoritative summaries of current work in areas in which there is at the moment much research activity. The full discussions accompanying each paper constitute a helpful feature of the volume.

CARL HARTMAN

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Methods of Theoretical Physics. pt. I and II. Philip M. Morse and Herman Feshbach. McGraw-Hill, New York–London, 1953. xxx + 1978 pp. Illus. $30 the set; $15 each volume.

THIS voluminous work treats neither physics nor mathematics as such, but it gives a comprehensive exposition of the mathematical tools that the theoretical physicist or applied mathematician must know how to use. Emphasis throughout is on the field constructs in terms of which most classical and modern theoretical physics is best formulated.

Although the work is prepared as a textbook for a first-year graduate course, I feel that the exposition is somewhat too condensed, and hence too difficult to read, for the book to be widely used by students. It is more of a treatise than a textbook—a treatise that should furnish invaluable reference material for student, professor, and research worker alike. All physicists should feel greatly indebted to Morse and Feshbach for some 8 years of arduous labor in assembling in one place for the first time all, or at least almost all, the mathematical ideas employed in the field-theory formulations of mechanics, heat, light, sound, electromagnetism, and 20th century physics.

GEORGE SHORTLEY

Operations Research Office, The Johns Hopkins University

Transactions and Proceedings of the Fiji Society. vols. 2–4. Fiji Society, Suva, Fiji, 1953. Vols. 2 (1941–44), 3 (1945–47), and 4 (1948–50), 3 guineas (Fijian), about $8 per set; 25 shillings, about $3.20 per volume.

THE most active local association of individuals concerned with the scientific development of the Pacific is probably the Fiji Society, an organization with headquarters in Suva. Founded in 1938 as the Fiji Society of Science and Industry (its name was shortened in 1947), the society has promoted a high degree of interest in Pacific scientific problems. Its scope, although centering in Fiji, extends to all the Pacific island groups. The papers presented at monthly meetings are varied and of high quality.

Since its organization the society has published an annual *Transactions and Proceedings,* but the editions have been small, and therefore the work of the organization is not widely known. In 1953 the society under-

took to reprint its *Transactions and Proceedings,* and these are now available in uniform volumes. The format and printing are of high quality.

In content, these volumes set a high standard of merit. The subjects covered include anthropology, ethnology, zoology, botany, forestry, geology, meteorology, public health, history, and economics. About 85 papers are presented, and the list of contributors includes many individuals who are leaders in the development of Pacific science—W. J. Blackie, R. A. Derrick, W. R. Dyer, Harold Gatty, C. Harvey, H. W. Jack, R. J. A. W. Lever, B. E. V. Parham, G. R. Roth, C. R. Turbet, and others.

I believe that these volumes belong on the shelves of all institutions concerned with science in the Pacific area. The Fiji Society has done a real service by bringing together, in such pleasing form, papers of outstanding merit, which otherwise might be overlooked by the scientific public. The future work of this active organization deserves every encouragement.

Orders should be addressed to the Treasurer, Fiji Society, P.O. Box 358, Suva, Fiji. Volumes 1 (1938–1940) and 5 (1951–53) are to be published in 1954, and it is planned subsequently to issue a new volume each third year.

A. C. SMITH
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A Bibliography of the Research in Tissue Culture: 1884 to 1950. An index to the literature of the living cell cultivated *in vitro.* vols. I and II. Margaret R. Murray and Gertrude Kopech. Academic Press, New York, 1953. xxviii + 1741 pp. $24 per set.

THESE remarkable volumes constitute a veritable textbook of research and a stimulating dictionary of tissue culture. The nature of the subject headings reveals the wide experience of Margaret Murray and her scholarly insight into the biological problems of living cells *in vitro.* Murray and Arthur Purdy Stout, together with Carrel, Lewis, Harrison, A. Fischer, Strangeways, Canti, Fell, R. C. Parker, Robert Chambers, George Gey, Ludford, Pomerat, and several other notable scientists are pioneers in the development of cellular physiological aspects of tissue culture. From the outset they recognized that *in vitro* tissue studies are too often engulfed in a Minos labyrinth of technical gadgetry. One of Murray's earliest manuscripts, if not her first, dealt chiefly with the secretory function of ovarian follicular cells of the cricket, not with the technical details of the apparatus. Her great contributions concern ossification, regeneration, and *in vitro* histogenetic classification of human tumors.

Murray's new volumes on the literature are not merely a compendium of 86,000 entries of 15,000 original articles of the 29,000 that the author has read. They suggest problems of histophysiology in relation to mitosis, nucleoproteins, trace metals, carcinogenesis, irradiation, phospholipids, hormones, temperature, leukemia, mitochondria, respiratory enzymes, embryonic differentiation, grafting, cataract, liver function, neurilemma, and many other matters—formulated in a touch-of-Midas fashion that will capture the earnest attention of both the experienced investigator and the beginning student of tissue culture. I commend this work, not only to those in tissue culture, but also and perhaps chiefly to general physiologists, cytologists, embryologists, pathologists, and cellular pharmacologists. The authors have skillfully classified and correlated our vast knowledge of the various aspects of the cell. Murray's volumes should be at the hand of every investigator in these fields for constant reference. The untold value of these important books justifies the tireless effort of the authors for more than 5 years.

The two volumes of 1741 pages are an alphabetized and cross-indexed outline of authors and subjects. I searched for the reference to nearly 100 articles that are most familiar to me and found that each article was carefully listed not less than three times, and many of them were listed five times in full detail, the author, title, and journal citation of the full article being given as well as absrtacts of it from *Biological Abstracts, Chemical Abstracts,* and one of the Zentralblatt journals, and often with a reference to the abstract of a speech delivered on the same paper in the proceedings of a scientific meeting (even though it may have been presented under slightly different title at two different meetings in the same year). This appears to be wasteful, and I wondered whether the reader could not be expected to read the original paper and abstract it himself.

An article by Jorstad was listed three times in full repetitive detail on a single page (1067) under mitosis and twice elsewhere. Three papers by Porter *et al.* were listed identically in detail eight times. Some of Ludford's papers were listed 10 times. Three papers by Nettleship were listed six times to total 50 lines, or half a page. The startling finding of Albert Fischer, of Earle, and of Firor and Gey that fibroblasts become malignant *in vitro* was cited in detail several times verbatim. Every paper I studied was repeated in full, a few as many as 10 times. It seemed that one listing in detail under the senior author's name would be sufficient with a single line, instead of four or five lines each time, for the other cross references. However good and convenient this may be in not having to turn the pages it seems to me that if a prospective researcher must be lured with such expensive bait, then I must question the sincerity of his interest in research! I would not be honest as a reviewer if I did not say that by rough calculation and some assumption that perhaps a large number of titles were listed repeatedly, I estimated that the size of these volumes could have been reduced by editing to a total of perhaps 900 pages, or even 700. Articles from popular news magazines and commercial publications are listed. It was, I suspect, difficult to draw a line in respect to the term *original research literature.*

Abbreviations of periodicals should be called to the attention of the reader. Many of them do not follow standard abbreviations, even though recommended by the journal itself or by abstracting journals. As an editor, I could scarcely help noticing that the *Journal of the National Cancer Institute* is listed as "U.S. Nat. Cancer Inst. J." and differently in the text, and that the *Proceedings of the Royal Society of London [B]*, is shown under "R." *Science* is listed as from Cambridge, Mass. *Archives of Pathology* is listed as "Arch. Path., Chicago," and the addition of Chicago is an unnecessary setting of type. These listings, as well as several others, should be corrected by prospective authors in the interest of editorial accuracy to avoid confusion in references.

These excellent volumes will serve as a beacon research light that will not soon fade. They lead to fascinating corridors of what the future may be in our understanding of the physiology and morphogenesis of the living cell. Margaret Murray and her coauthor are to be congratulated for a great contribution to tissue culture. The fewness of errors bespeaks their skill in such a vast task.

Ross C. MacCardle
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The Behavior and Social Life of Honeybees. C. R. Ribbands. Bee Research Association, London; Hale Pub., Hopeville, Ga., 1953. 352 pp. Illus. plates. $4.50.

In the words of the author, this is an attempt to provide a comprehensive review of knowledge of the behavior and social life of honeybees. Written in a concise, easy-to-read style, it should be of wide interest to all who are interested in biology as well as to those with specific interest in the sensory behavior of organisms or in apiculture.

Following a brief introduction, part I deals with the roots of behavior: the senses, the glands, and the structural differences between workers, queens, and drones. Part II deals with the individual behavior of bees in the field, including factors influencing field activity, foraging range, crop constancy, division of labor, and mating behavior. Part III deals with communication between honeybees: the recruitment of crops, the selection of a home by the new swarm, the defense of the community, and the language of bees that indicates what food is available, its direction, and its distance from the hive. Part IV deals with the life of the queen, workers, and drones within the community.

The author attained a considerable degree of success in organizing a vast amount of subject matter for both popular reading and scientific source material. In a sense, the book is an annotated bibliography pertaining to the subject scope. The work of some 400 authors covering 700 publications is summarized, coordinated, and commented upon in the light of Ribbands' own research in the field of bee behavior.

Although a considerable amount of data are presented from the publications summarized, research workers interested in a specific phase will need to review the original papers in order to obtain the authors' viewpoints, scope of study, and conclusions. Some of the papers reviewed, especially those closely related to the author's own research, are handled in an effective manner. Even though some papers may have been deemphasized or misinterpreted, the literature drawn on is so vast that the author is to be commended for his well-organized, concise treatment of the subject.

Excellent photographs are used in 11 plates, and the line drawings and charts are beyond criticism.

C. L. Farrar
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The Monkey Book. Ernest P. Walker. Macmillan, New York, 1954. 153 pp. Illus. $6.50.

The keeping of monkeys in captivity has its problems and satisfactions. Ernest Walker's book was written to answer the chief types of questions asked by people who have (or who are interested in having) monkeys as pets. Popular in style, with clear brief treatment of well-chosen topics, the book emphasizes the importance of choosing the right kind of monkey for a pet, of keeping it warm, properly fed, and contented, and of accepting it for what it is, as a monkey, and not trying to make an inferior human being out of it. Practical advice dominates not only the general account (Part I) but also that of the genera and species (Part II). The latter part should be interesting, even to casual readers not intending to keep pet monkeys, in that it illustrates the remarkable differences in size, form, habits, and dispositions occurring within a broad group of Primates.

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American Seashells. R. Tucker Abbott. Van Nostrand, New York, 1954. xiv + 541 pp. Illus. + plates. $12.50.

This book has been so long announced and anticipated that it is almost a legend. Here it is, at last, and it is pleasant to report that it fulfills all expectations. Intended primarily as a popular "handbook" for serious amateurs, it will also be of great service to conchologists, ecologists, and general practitioners. The illustrations are numerous and excellent, especially the color plates, which outclass those of all competitors. The type is large, and both text and illustrations are well cross-referenced. While the result of these niceties is a large handsome volume that will embellish any library table or shell cabinet, the book's size prevents it from being carried about easily.

As the title implies, this is a guide to both Atlantic and Pacific species. Such treatment has its disadvantages, but publishing economics outweigh problems of

presentation. The author has avoided the pitfalls as much as possible by arranging his plates according to region and by stating ranges before the rest of the text under each species, and he has managed to include a surprising number of species heretofore ignored by such popular guides. This is especially true of the pteropods and nudibranchs (although some of the common Pacific coast sea-slugs have been overlooked). Occasionally species from Central America have been illustrated but not mentioned in the text, which adds to the total number of species that may be identified with the aid of this book. There are two large indexes. A heroic effort has been made to straighten out the sadly tangled nomenclature of the common species, and synonyms are given in every case. Sometimes the suggested common names are not too happy choices but this is a minor failing common to such handbooks. There are remarkably few typographical errors for a work of this size and complexity.

This book should stand for years as the standard general reference, the essential cornerstone of every collector's library. The price, indeed, is steep, but no one who delights in sea shells will begrudge it, and certainly it must be less than the cost of an excursion or two to the beach.

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Animal Control in Field, Farm, and Forest. W. Robert Eadie. Macmillan, New York, 1954. viii + 257 pp. $3.75.

THE field of wildlife management emphasizes ways and means of increasing populations of desirable or interesting wild animals. An equally important facet of the field, but one less studied or written about, concerns our endeavors to decrease or control undesirable or destructive wild populations. Up to now the literature on animal control has been widely scattered in journal articles and government bulletins. Eadie's volume is the first serious effort to compile and synthesize current information on this subject.

The work is intended for the lay public, "gardeners and farmers, . . . nurserymen and foresters," hence the language is nontechnical and the text is not cluttered with citations. In phylogenetic order all American mammals that frequently cause economic damage are discussed under the headings (i) identification and habits, (ii) economic status, (iii) control, and (iv) natural enemies. Recommendations for control are specific and easily understood. Types and sizes of traps are specified, recipes for mixing poison baits are given in detail, methods of fencing out or excluding animals are well described. Each chapter concludes with a selected bibliography of pertinent literature.

As a handbook for amateurs, the volume suffers seriously in being completely unillustrated. Without photographs or even line drawings, it is hard to see how an untrained gardener, farmer, nurseryman, or forester could recognize which animal he wants to control. Often enough it is merely the sign of damage and not the animal itself that is available for inspection the morning after. A popular handbook should, it seems, be well illustrated, above all else.

I was disappointed not to find a general discussion of the natural ecologic processes and relationships that are known to control all wild populations. Not that Eadie lacks the ecologic point of view—he shows it clearly in chapters on ground squirrels, jack rabbits, and here and there throughout the book. But thinking again of the lay reader for whom this work is intended, an introductory chapter or two on population dynamics would have greatly enhanced the educational value of the volume.

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Avian Physiology. Paul D. Sturkie. Comstock, Cornell Univ. Press, Ithaca, N. Y., 1954. 423 pp. Illus. $6.

THIS book claims to be "the first one in any language devoted to the specialized physiology of birds." It is intended primarily for use as a textbook in courses in avian physiology offered by poultry departments. Its coverage of physiology with special reference to birds is reasonably broad, although five out of 21 chapters deal with the endocrine glands. Other subjects covered in one or more chapters include blood, circulation, electrocardiography, respiration, body temperature, energy metabolism, the alimentary canal, carbodydrate metabolism, the kidneys, reproduction, and the special senses. The central nervous system and "nonspecial" senses are mentioned only in passing.

Although it is presumably intended for students who have not studied physiology elsewhere, many basic physiological principles receive surprisingly little attention. For example, on p. 51 the interplay of respiration and blood pressure is dismissed by the statement "Blood pressure . . . usually falls in inspiration and rises on expiration. The explanations for these changes are numerous and complicated (see Wiggers, *Physiology in Health and Disease,* 1949)." Nor is the book free from misleading statements such as "When the concentration of a substance in the tubules and urine is higher than that in the plasma or glomerular filtrate, this is evidence of tubular secretion" (p. 211). Except for a statement that "the kidney tubules also reabsorb water" there is no clear explanation of the effectiveness of filtration plus reabsorption of water as a means of concentrating materials in the urine.

This book also encounters a fundamental difficulty familiar to all physiologists who attempt to deal with animals other than man or the traditional laboratory mammals. There is so much more solid data available from physiological experiments with mammals that many physiological questions about other animals can best be answered, since there is usually no direct experimental information available, by analogies with

mammalian physiology. For this reason, one finds that much of this book is a restatement of classical mammalian physiology, together with some discussion of the degree to which it seems applicable to birds. Such analogies have a real degree of validity because the general physiologist is essentially correct in holding that physiological mechanisms are much the same regardless of the organism in which they are found. Yet there are differences, at least of magnitude and relative importance of particular physiological mechanisms, even between closely related species, dogs and cats, rabbits and rats, or ducks and chickens. Since biologists are interested in real animals as well as in abstract principles, they will find this a useful review of many papers dealing with assorted aspects of avian physiology. Moderately extensive bibliographies are provided at the end of each chapter. As a contribution to comparative physiology, the motto of this book might be *"Vive la différence!"*

DONALD R. GRIFFIN
Biological Laboratories, Harvard University

The Trees and Shrubs of the Southwestern Deserts. Lyman Benson and Robert A. Darrow. Univ. of Arizona Press, Tucson, and Univ. of New Mexico Press, Albuquerque, ed. 2, 1954. x + 437 pp. Illus. + plates. $8.50.

THE blurb on the dust jacket begins "Off to Palm Springs or on a junket to Texas? The two eminent botanists who have written this book give you in brief nontechnical language a comprehensive description of the brilliant trees and shrubs of the deserts over which you will travel." The authors themselves refer to the book as a "semi-popular or semi-technical manual." It is nothing of the sort. It is a technical, comprehensive guide to the flora of our southwestern deserts, a reissue in book form of the attractive low-priced, paperbound manual originally issued by the University of Arizona and now out of print.

The 34 plates, nine of them in color, are the features most likely to appeal to the general public. The 84 pages of distribution maps and attractive line drawings would be helpful and usually intelligible to the amateur botanist. The introductory chapters on desert vegetation, scientific nomenclature, and taxonomic terminology help make this a good textbook for use in advanced undergraduate courses in taxonomy in the Southwest. The notes on geographic distribution and economic uses appended to many of the descriptions will be of interest to those with a scientific understanding of range management.

Semipopular it is not. The 37-page appendix, for example, is given over completely to taxonomic details of synonomy and type collections. Even in its technical aspects the volume represents, to those who know the southwestern flora, more of a competent compilation than a distillation based upon a real understanding of these plants acquired by day-to-day and year-to-year association.

Comprehensive it is. The inclusion of virtually all the natively growing trees and shrubs from Palm Springs, California, to El Paso, Texas, is its chief scientific merit. The notes on distribution, Indian uses, and range qualities seem to be born out of experience and are of general interest, although not very extended. To the ordinary nontaxonomic scientist, let alone to the general public, the most interesting features are the distribution maps, the line drawings of certain desert plants, and the well-printed photographs, the best of which are handsome indeed.

The volume is written in labored, pontifical semiscientific jargon. To one with a good scientific vocabulary, it is clear but not attractive. The following excerpts were selected by opening the book at random, avoiding all purely technical passages (which make up the bulk of the volume), and making no conscious effort to sift out phrases that are below the general average.

> This plant is not to be confused with Strelitzia, also known as bird-of-paradise and related to the banana . . . in experiments conducted at the Santa Rita Experimental Range, fairy duster plants were found to be highly palatable to captive mule and white-tailed deer but of little forage value to jack rabbits . . . white thorn flowers make a definite contribution to the annual production of desert honey . . . conservative policy with respect to recognition of species is followed here for the following practical reasons as well.

The authors merit the congratulations of fellow-scholars for this expert compendium, attractively put together. They also deserve personal copies of Fowler's *Modern English Usage* and the admonition to study them earnestly at regular intervals. Although not recommended for the general public, this is an attractive and, for some purposes, an excellent volume. It is a good textbook and a first-rate book of reference.

EDGAR ANDERSON
Missouri Botanical Gardens, St. Louis

Lower Tertiary Foraminifera of the Qatar Peninsula. Alan Hilder Smout. British Museum (Natural History), London, 1954. ix + 96 pp. Illus. + plates. £2 5s.

THE Qatar Peninsula is on the Arabian shore of the Persian Gulf, just south of Bahrein Island, an important petroleum producing area. The Foraminifera are principal means of working out the geology of the area. The Foraminifera are from five deep wells; unfortunately, the depths from which the fossils came are not given. The usual small Foraminifera are not preserved, and all the 36 species discussed are large, with thick calcareous tests. The ages of the rocks identified extend from Middle Eocene (with six species), Lower Eocene (with six species), Paleocene (with 23 species), and Late Cretaceous (with one species).

Most attention is given to the superfamily Rotaliidea, with a new diagnosis of the superfamily, and a statement of morphogenetic principles, plans of growth, wall

structure, pillars, canal systems, apertures, and phylogeny. The rotaploid genera *Rotalia, Lockhartia, Sakesaria, Dictyoconoides,* and the new genera *Kathina, Dictyokathina* and *Daviesina* are described. Also considered are *Miscellanea, Operculina,* and *Nummulites.* Two genera of the superfamily Discorbidea, *Asterigerina* and *Linderina,* one of the Miliolidea, *Alveolina,* and one of the Lituolidea *Dictyoconus* are described and figured.

Many new ideas on the structure and relationships of the genera named are proposed. It is rather remarkable that *Rotalia trochidiformus,* characteristic of the Middle Eocene of the Paris Basin, should occur only in the Lower Eocene of the Qatar Peninsula. The number of new genera (3) and new species (19) makes the distinguishing of the similar genera and species a disconcerting task. The keys are very useful. Few of the forms occur in North America, but the work will be very useful for paleontologists of the Mediterranean region and eastward.

The book is a large quarto in size, splendidly printed, and illustrated with 240 beautiful collotype figures of the exterior and interior of all the described species.

J. J. Galloway
Department of Geology, Indiana University

Plant Growth Substances. L. J. Audus. Interscience, New York, 1953. xix + 465 pp. Illus. + plates. $6.50.

In *Plant Growth Substances,* Audus has tried to write a book that is "planned to cater for all classes of reader," both plant physiologist and layman. This is a difficult task to set oneself: either the plant physiologist will be bored with elementary details or the layman will be overcome with esoteric ones. On the whole, Audus has made an excellent compromise between the needs of these two groups. The basic emphasis is on practical applications, although full details of rates, time of application, sources of chemicals, and so forth, are restricted to tables, for the most part. (The tables are collected at the end of the book as appendixes.) Some chapters cover the rooting of cuttings; the use of auxins in inducing fruit-set, in preventing bud-growth in stored vegetables and stored trees, and in preventing premature fruit-drop in apples and other fruits; the use of weed killers; and a discussion of experiments on "flowering hormones." For each of these highly practical subjects, the author has given an excellent summary and discussion of the more "theoretical" research upon which our knowledge of the phenomena is based. Quite a bit of relatively unknown research from British experiment stations has been included, much of it originally buried in annual reports of the stations. However, this too, has disadvantages, for the discussions of just how British varieties of apples react to growth substances is of little interest to American laymen or physiologists. I am sure that a similar lack of interest will be shown by the English to details of results on apple varieties grown in the U.S.

A chapter on the chemistry of the auxins is particularly well organized, although Audus' ability to instill order into a chaos of experimental results can be seen throughout the book. Most of the illustrations are new and good. The photographs of the *Avena* bioassay for auxin are particularly useful to a lay audience, for they make clear how small the *Avena* seedlings really are. In a number of cases the data of other workers have been re-worked or tested for statistical significance, often with illuminating results. All in all, this is a useful and well-written book.

William P. Jacobs
Biology Department, Princeton University

In Quest of New Ethics. Charles Mayer. Beacon Press, Boston, 1954. xiii + 321 pp. $4.

Part One, "Inquiry into principles," seeks a basis for ethics in a mixture of rationalism and science unlikely to impress very strongly the majority of scientists who may read it. The following example is cited to support this opinion:

> Now if it is admitted, as seems probable, that unicellular beings experienced a pleasurable sensation or at any rate a feeling of relief at the time of their division into two distinct cells, then all sexuality is explained at the point of its origin.

Part Two, "Application of the principles," is much more stimulating. It deals with such subjects as capitalism and colonialism (the author plugs for both), wars and political unrealism. These are realms in which I do not claim to be an "intellectual," and I possess only the competence of a lay citizen, but in my opinion the author states his views on these matters with a robust realism that challenges the mixture of uncritical idealism and self-interest with which this nation staggers under its unwanted burden of world responsibility. One wonders what answer many Americans would give to the following criticism:

> Both North Americans and South Africans, thoroughly imbued with the most stupid prejudices against the races which come under their own laws, denounce European colonialism as it exists in Africa.

The following could help us to appreciate the French attitude toward Indo-China:

> It is at once comical and lamentable that the old colonial powers seem to be enacting the role of the old patriarch on his way to senescence, whose function is to support children not his own who think of nothing but getting rid of him. To continue indefinitely to pour blood and money into territories which one knows will be taken away from one in the near future without any indemnity is pure idiocy.

In discussing wars, Myer says:

> What is serious, and what leads to tragic misunderstandings and perpetuates sterile conflicts, is the fact that the war leaders themselves come to believe in high-sounding slogans devoid of practical sense, such as President Roosevelt's demand for "unconditional surrender." Unless one's name is Hitler, one cannot

> condemn a whole enemy people to die or even to decay economically to the point where they constitute a gangrenous infection to the victors themselves.

Concerning American counter-propaganda against Russia:

> Every regime and every government must have its own reason for being. Thus the Communist propaganda in the United States, followed by the American counter-propaganda against Russia, helped greatly to consolidate Stalin's power at a time when the Russian people, freed at last from fears of a Nazi invasion, had begun to dream of profiting from their hard-won victory in a new era of peace and freedom.

One may or may not accept Mayer's ethics of "liberal and progressivist materialism," but he raises questions that could well occupy some of the attention the nation is now devoting to matters of far less importance.

JOEL H. HILDEBRAND
Department of Chemistry and Chemical Engineering, University of California, Berkeley

Field Crop Production. Agronomic principles and practices. Harold K. Wilson and Will M. Myers. Lippincott, Philadelphia, 1954. viii + 674 pp. Illus. $6.

THIS is a compilation of the names, properties, and practices that have been accepted in agriculture, especially in the United States, in connection with growing and using various field crops.

Of the 650 pages of this student textbook, more than 500 are given to cataloging the many crop plants. This listing includes adaptation, botanical characters, geographic distribution, methods of establishment, fertilization, use, seed production, diseases, insects, and so forth, for each crop. They have been grouped as annuals and perennials, as crops grown for forage and those grown for seed, and according to climatic geographic areas of higher or lower temperatures and of higher or lower annual rainfalls. The remainder of the volume is given to the settings and managerial phases for crop production—namely, soil, climate, tillage, rotations, and other general factors commonly recognized in farmer experience—higher agricultural production, and wider use of field crops. This represents a revision and an extension of previous works of a similar purpose, a work which could well be done at this time.

Since this taxonomic listing became so voluminous, the authors apparently found no place for crop physiology. They could not then report on the differences in the nutrition of various crops in relation to the pattern of soil fertility as it is influenced by the climatic forces that develop the soils to control crop physiology to no small degree.

The authors have done well in this presentation. We shall be awaiting the next work in their readily readable style when they, or their proteges, will organize crop thinking with the soil as the nutritional basis for plants and with plant growth related to soil fertility rather than vice versa, or with the soils in general related to plant growth.

This publication may well have a place on the bookshelf of the farmer, the agronomist, or others aiming to keep abreast of the efforts to find crops for agricultural production of fiber, feed, and food in an area as extensive as the United States.

WM. A. ALBRECHT
Department of Soils, University of Missouri

A Philosophical Study of the Human Mind. Joseph Barrell. Philosophical Library, New York, 1954. xii + 575 pp. Illus. + plates. $6.

IN addition to teaching philosophy at Beloit College, Barrell also has had experience as a worker in a sanitarium,—a combination of interests that accounts for the unique character of this book. It is intended primarily as a synthesis of contemporary psychological thought in its bearing on the problem of the types of personality, and it is concerned essentially with the psychology of the normal. While the influence of William James and C. G. Jung is apparent throughout, the author has also incorporated the concept of the conditioned response of the behaviorists and the Freudian theory of development without the background of neurosis. The philosophic standpoint is that of pragmatism, an approach that Barrell anticipates will release the present study from the charge of mere "armchair" speculation. The final purpose of his study is to furnish a central, positive system of thought on which to range all normal personalities, the psychopathic personality being placed on the outer edges. It is concerned primarily with the conscious rather than the unconscious mind and with a personality's reaction to a given situation. According to Barrell, "man is not what he is, but what he is aroused to be."

The order of the functions of the mind is said to be perception, emotion, intellect (memory and imagination), and volition. There is a basic distinction between primitive and abstract minds. On the primitive plane, mental processes occur without language; one can notice, remember, and imagine with only concrete images. On the abstract plane, words are utilized and the individual thinks with symbols instead of with things. The abstract mind exists parallel with this primitive mind, and individuals are said to differ in their ability to think either concretely or abstractly. The unusual development of man's abstract mind, the author believes, is largely social in its origins; man evolved psychically with the evolution of his communal mind. With society came language, and with language must have come this second order of thinking. Barrell's own preference is for concrete, rather than abstract, thought, and this is demonstrated by his frequent use of charts, case histories, and references to literary works to illustrate his theoretical analyses. This preference also explains why he rejects depth psychology in favor of a more objective trait psychology.

One of the most interesting chapters is the one devoted to the mood-cycle. The emotional mood-cycle of women is one of hope and fear, because they are to a great extent dependent on others. The mood-cycle of men is one of anger and conviviality in proportion to the activity and independence of their lives. There is also the joy-depressoid cycle that forms the basis for personality differences in reactions to a given environment. Hence, the latter is said to be the environmental type and intersexual. There are also many hybrid types. Much attention is given to Jung's discovery of the difference between extraversion and introversion. The introvert is defined as one who is at the center of himself; the extravert is one who is at the center of the world.

One of the book's most serious limitations is its lack of concern with contemporary studies of personality in culture. Had the author utilized recent personality-culture research instead of secondhand, dull, literary references, his work as a whole would have gained in interest and scientific value. Furthermore, his distinction between primitive and abstract minds is of questionable ethnologic value and is far from self-evident to philosophers who share Cassirer's philosophy of symbolic forms as basic to all thought. With the exception of the introductory chapters, the book as a whole constitutes difficult and abstract reading in spite of the author's attempts to make his thought concrete. Nevertheless, it does have genuine originality and philosophic significance regardless of the practical utility of its numerous classification schemes of personality types for the psychologist.

DAVID BIDNEY
Department of Anthropology, Indiana University

Essays in Sociological Theory. Talcott Parsons. Free Press, Glencoe, Ill., rev. ed., 1954. 459 pp. $6.

HENRI POINCARÉ once remarked that sociology is the science with the most methods and the least results. This consequence of the crude empiricism that characterized much sociological research in the past had its roots, no doubt, in the neglected state of systematic sociological theory. Whatever theory there was seemed to the research worker, in the words of Charles Beard, "irrelevant, incompetent, and impertinent." It is gratifying, therefore, to note the increasing evidence that sociology is becoming more alert to the fundamental requirements of theory-oriented research and research-oriented theory. Part of the evidence is this revised edition of Talcott Parsons' 1949 collection of essays in sociological theory.

The emphasis in this revision is on empirical applications of theory and on broad comparative treatments of social systems and large-scale societies. To permit the reader to observe the process of theoretical development, the 19 essays are arranged in the order of their original publication without regard to subject matter. They cover a span of 15 years, 1938–53, and they are reprinted from some 14 different technical periodicals and publications. In subject matter, they include the role of ideas in social action, age and sex and kinship systems, social stratification, fascist movements, the legal profession and the professions generally, population, psychoanalysis, sociology of religion, economic motivation, and related topics.

Parsons is one of America's foremost sociological theorists. As a result of his participation in the trial marriage of theory and research technique that took place at Harvard University in 1946 with the establishment of the Laboratory of Social Relations, he is currently dedicated to the construction of conceptual schemes that can be operationally tested with rigorous procedures and standards of validation. The later essays in this volume are suggestive of the high fertility of this Harvard marriage of theorists and empirical researchers. Unfortunately, Parsons' stylistic complexities create communication barriers that prevent him from having the broad and effective influence outside of sociology that his scholarly, rigorously reasoned papers so richly merit.

HARRY ALPERT
National Science Foundation

Biological Effects of External X- and Gamma Radiation, pt I. Raymond E. Zirkle, Ed. McGraw-Hill, New York-London, 1954. xxvi + 530 pp. Illus. $7.25.

THIS volume consists of a series of 22 papers by 31 authors, and the work is largely based on reports completed by the end of 1946. It gives testimony to the impressively competent planning, the painstakingly diligent execution, and the critical evaluation that went into the wartime effort. The results are solid foundations for our knowledge of acute and chronic effects of radiation on laboratory animals, information that was and is partial basis for computations of "permissible exposure" doses to human beings. Much of the detailed material is now presented for the first time in book form, having previously existed in limited circulation reports.

The first five chapters are devoted to the studies of the late Egon Lorenz and his associates at the National Cancer Institute. They deal with the effects of long-continued total-body gamma radiation on mice, guinea pigs, and rabbits. The observations included records of change in longevity, carcinogenesis, chronic hematologic changes, fertility, and pathological changes at various gamma-ray intensity levels. The sixth chapter applies the rather complex results to the problem of human radiation protection.

There are eight chapters from the University of Chicago dealing with hematologic effects of x-rays in large animals, rabbits, and dogs. Much of this work was done by Leon Jacobson and his associates.

Effects on leucocytes, on red blood cells, and on animals with preexisting anemias are investigated in detail. The hematologic changes after repeated doses are also described.

The remaining chapters deal with biochemical and immunological effects induced by x- and gamma rays. E. S. Guzman Barron and his associates describe changes in the dog plasma electrophoretic pattern after exposure to radiation; effects of x-rays on tissue metabolism, chiefly on respiration of tissues and oxidation of substrates requiring sulfhydryl enzymes; a study of radiation effects on enzymes *in vitro*. Interesting chapters describe changes in the ultraviolet absorption spectrum of urine and attempts for chemotherapy of the radiation syndrome.

This highly technical volume will serve as indispensable guide and reference source to those who actively carry out animal experimentation in the field of radiation and tumor induction. It contains valuable chapters for those interested in foundations of health protection and in hematologic, metabolic, and biochemical effects on animals. Some of the material has, however, been superseded or elaborated by more recent discoveries. I feel, therefore, that a reader with only casual interest can find more suitable books in the literature for his purpose. The volume was intended to be an account of original investigations over a span of a few years, and as such it attests to the excellence of its authors and to the competence and care of its editor.

CORNELIUS A. TOBIAS
Division of Medical Physics, Donner Laboratory, University of California, Berkeley

Method and Perspective in Anthropology. Papers in honor of Wilson D. Wallis. Robert F. Spencer, Ed. Univ. of Minnesota Press, Minneapolis, 1954. xii + 323 pp. $4.50.

THIS Festschrift for Wilson D. Wallis, who just retired after 30 years of successful teaching and research at the University of Minnesota, attempts to overcome some of the well-known defects of the species Festschrift. Its 12 papers form a symposium on methods in anthropology, and even greater unity is achieved through a final article by Alfred L. Kroeber, the universally admired dean of American anthropologists, in which he comments on the different contributions. The papers of M. J. Herskovits, Sister M. Inez Hilger, and Elizabeth Colson most competently discuss diverse aspects of ethnographic field methods. David G. Mandelbaum and Alan R. Holmberg contribute interesting field experiences. The three following articles are devoted to some basic problems of cultural anthropology: the late Ralph Linton deals with universal values, Robert F. Spencer with the relationship of the humanities and anthropology, Erwin H. Ackerknecht with the history of the comparative method. Lloyd A. Wilford analyzes aspects of archeological method; Joseph H. Greenberg makes a very original contribution to linguistic methodology; Raymond V. Bowers gives his opinion on research methodology in sociology. In spite of the somewhat messianic wording, I was very much impressed with Omer C. Stewart's "The forgotten side of ethnogeography." For a change, Omer Stewart shows not what nature did to primitive man but what primitive man did to nature (in the concrete case of the creation of prairies through continuous firing of forests and grasslands).

This volume is a worthy tribute to a worthy man. The editor, R. F. Spencer, is to be congratulated for having brought together so many contributions of a high quality in a volume which should be widely read as a very valuable contribution to anthropology.

ERWIN H. ACKERKNECHT
Department of History of Medicine, University of Wisconsin Medical School

1954 Medical Progress. A review of medical advances during 1953. Morris Fishbein, Ed. Blakiston, New York, 1954. x + 345 pp. $5.

MEDICAL progress is so rapid today and has so many facets in so many diverse fields that no one can even begin to keep abreast of research developments in more than a very narrow segment of this science. Even the usual subdivisions of medicine are so broad that the specialist can have no more than a summary knowledge of the latest developments. A concise and authoritative review of a given topic thus offers the only means for the physician to keep in contact with the rapid march of medical progress. This need has been well recognized by certain medical journals that make a regular practice of including articles of a review nature.

The present volume attempts to bring together in book form a series of review essays in some 20 fields. Written by highly competent and carefully selected specialists, each article summarizes the significant developments of 1953. In his preface, the editor explains that the present volume is a sequel to the one that appeared a year earlier, *Medical Progress 1953*. He further points out that certain chapters

> . . . are duplicated as to subject and authors . . . [while] other chapters [of the earlier volume] are purposely omitted . . . because progress has not been so great or because it seemed desirable to introduce new subjects or new authors with a different point of view.

To the 19 chapters by 27 collaborators, the editor adds a summary chapter on topics not covered.

This is a highly authoritative book of great value to practitioners of medicine and to all engaged in research in the broad fields of medicine. The reader will find it an invaluable aid in his endeavor to keep abreast of the fast-moving field of medical progress.

GAYLORD W. ANDERSON
School of Public Health, University of Minnesota

Books Reviewed in SCIENCE

1 October

The Freshwater Fishes, vol. I, Vianney Legendre (Quebec Biological Bureau). Reviewed by W. A. Clemens.

Advances in Protein Chemistry, vol. VIII, M. L. Anson, Kenneth Bailey, and John T. Edsall, Eds. (Academic Press). Reviewed by R. H. Locker.

A Monograph of the Fungus Genus Cercospora, Charles Chupp (Charles Chupp). Reviewed by A. W. Dimock.

The Collected Papers of Peter J. W. Debye. (Interscience). Reviewed by U. P. Strauss.

Dynamics of Growth Processes, L. M. Kozloff *et al.* (Princeton Univ. Press). Reviewed by H. Selye.

Progress in the Chemistry of Fats and Other Lipids, vol. 2, R. T. Holman, W. O. Lundberg, and T. Malkin, Eds. (Academic Press). Reviewed by H. H. Tomizawa.

Organic Chemistry, Reynold C. Fuson and H. R. Snyder (Wiley; Chapman & Hall). Reviewed by C. R. Dawson.

Cohort Fertility, Pascal K. Whelpton (Princeton Univ. Press). Reviewed by D. P. Murphy.

Methods in Medical Research, vol. 6, J. Murray Steele, Ed. (Year Book Pub.). Reviewed by W. Z. Hassid.

8 October

Government and Science, Don K. Price (New York Univ. Press). Reviewed by H. Alpert.

Proceedings of the Second International Congress on Rheology, V. G. W. Harrison, Ed. (Academic Press; Butterworths). Reviewed by D. C. Drucker.

Vapor Pressure of Organic Compounds, T. Earl Jordan (Interscience). Reviewed by G. W. Thomson.

Tissue Culture as Applied, Ren Kimura (Monksgaard). Reviewed by J. H. Hanks.

Copper, Allison Butts, Ed. (Reinhold). Reviewed by W. J. Crook.

Optical Workshop Principles, Charles Dévé (Hilger & Watts; Jarrell-Ash). Reviewed by L. Chalkley.

Matthews' Textile Fibers, Herbert R. Mauersberger (Wiley; Chapman & Hall). Reviewed by W. R. Brode.

Experimental Inorganic Chemistry, W. G. Palmer (Cambridge Univ. Press). Reviewed by L. F. Audrieth.

The Determination of Crystal Structures, H. Lipson and W. Cochran (Macmillan). Reviewed by R. Pepinsky.

Amebiasis, Ernest Carroll Faust (Thomas). Reviewed by K. R. Crispell.

The Present State of Physics, arranged by Frederick S. Brackett (AAAS). Reviewed by O. Oldenberg.

Problems of Consciousness, Harold A. Abramson, Ed. (Josiah Macy, Jr. Foundation). Reviewed by R. B. MacLeod.

A Field Guide to the Birds of Britain and Europe, Roger Tory Peterson, Guy Mountfort, and P. A. D. Hollom (Houghton Mifflin). Reviewed by D. C. Peattie.

Electronics, Thomas Benjamin Brown (Wiley; Chapman & Hall). Reviewed by L. O. Goldstone.

The Biochemistry of Genetics, J. B. S. Haldane (Macmillan). Reviewed by H. B. Chase.

15 October

Fundamentals of the Working of Metals, G. Sachs (Interscience). Reviewed by W. A. Backofen.

Tropical Meteorology, Herbert Riehl (McGraw-Hill). Reviewed by R. D. Fletcher.

Geometrical Mechanics and De Broglie Waves, J. L. Synge (Cambridge Univ. Press). Reviewed by P. Morrison.

Compounds with Condensed Thiophene Rings, Howard B. Hartough and S. L. Meisel (Interscience). Reviewed by S. Archer.

The Actinide Elements, Glenn T. Seaborg and Joseph J. Katz, Eds. (McGraw-Hill). Reviewed by J. O. Edwards.

Calculations of Analytical Chemistry, Leicester F. Hamilton and Stephen G. Simpson (McGraw-Hill). Reviewed by J. M. Schempf.

Animal Breeding, Laurence M. Winters (Wiley; Chapman & Hall). Reviewed by J. A. Whatley, Jr.

Fresh Water from the Ocean, Cecil B. Ellis (Ronald Press). Reviewed by G. O. G. Lof.

Titanium and Titanium Alloys, John L. Everhart (Reinhold). Reviewed by B. S. Mesick.

Biological Effects of External X and Gamma Radiation, pt. I, Raymond E. Zirkle, Ed. (McGraw-Hill). Reviewed by T. C. Evans.

Advances in Cancer Research, vol. II, Jesse P. Greenstein and Alexander Haddow, Eds. (Academic Press). Reviewed by S. Peller.

22 October

A History of Mechanical Inventions, Abbott Payson Usher (Harvard Univ. Press). Reviewed by L. J. Briggs.

The Physics of Experimental Method, H. J. J. Braddick (Wiley). Reviewed by V. E. Eaton.

The Microtomist's Formulary and Guide, Peter Gray (Blakiston). Reviewed by F. B. Johnson.

Instrumental Analysis, John H. Harley and Stephen E. Wiberley (Wiley; Chapman & Hall). Reviewed by H. A. Frediani.

Adhesive Bonding of Metals, George Epstein (Reinhold). Reviewed by W. E. Taylor.

The Design and Use of Instruments and Accurate Mechanism, T. N. Whitehead (Dover).

Spot Tests, vols. I and II, Fritz Feigl (Elsevier). Reviewed by P. J. Elving.

Semimicro Qualitative Analysis, Edwin O. Wiig (Van Nostrand). Reviewed by L. E. Malm.

Isotopic Tracers, G. E. Francis, W. Mulligan, and A. Wormall (Athlone Press; John de Graff). Reviewed by S. Udenfriend.

Industrial Stoichiometry, Warren K. Lewis, Arthur H. Radasch, and H. Clay Lewis (McGraw-Hill). Reviewed by R. R. Rothfus.

Induction and Dielectric Heating, J. Wesley Cable (Reinhold). Reviewed by E. L. Brancato.

Nuclear Reactors for Industry and Universities, Ernest H. Wakefield, Ed. (Instruments Pub.). Reviewed by R. D. Huntoon.

A Text-Book of Macro and Semimicro Qualitative Inorganic Analysis, Arthur I. Vogel (Longmans). Reviewed by E. B. Reid.

Laboratory Instruments, A. Elliot and J. Home Dickson (Chemical Pub.). Reviewed by D. E. Williamson.

29 October

The Cultivation of Animal and Plant Cells, Philip R. White (Ronald Press). Reviewed by D. W. Fawcett.

Science, Medicine and History, E. Ashworth Underwood, Ed. (Oxford Univ. Press). Reviewed by W. R. Amberson.

Electronics, George F. Corcoran and Henry W. Price (Wiley; Chapman & Hall). Reviewed by L. O. Goldstone.

The Permanent Revolution in Science, Richard L. Schanck (Philosophical Library). Reviewed by M. Bates.

Recent Progress in Hormone Research, vol. IX, Gregory Pincus, Ed. (Academic Press). Reviewed by D. C. Smith.

Chambers's Shorter Six-Figure Mathematical Tables, L. J. Comrie (Chemical Pub.). Reviewed by W. J. Youden.

Tables of Lagrangian Coefficients for Sexagesimal Interpolation (National Bureau of Standards). Reviewed by C. R. Cassity.

Die Bedeutung des Blutchemismus, Ernst Leupold (George Thieme; Intercontinental Medical Book). Reviewed by H. F. Winterkorn.

Communication Theory, Willis Jackson, Ed. (Academic Press; Butterworths). Reviewed by Jerome Rothstein.

Energy Metabolism and Nutrition, Raymond W. Swift and Cyrus E. French (Scarecrow Press). Reviewed by Samuel Brody.

New Books

Biochemistry of Cancer. Jesse P. Greenstein. Academic Press, New York, ed. 2, 1954. xiii + 653 pp. Illus. $12.

Hydraulic Systems and Equipment. R. Hadekel. Cambridge Univ. Press, New York, 1954. viii + 224 pp. Illus. $3.75.

Résistance et Soumission en Physio-Biologie. L'hibernation artificielle. H. Laborit. Masson, Paris, 1954. 120 pp. Illus. Paper, F. 650.

Antibodies and Embryos. F. W. Rogers Brambell, W. A. Hemmings, and M. Henderson. Athlone Press, London, 1951; John de Graff, New York, 1954. 103 pp. Illus. $2.25.

L'Instabilité en Mécanique. Automobiles, avions, ponts suspendus. Y. Rocard. Masson, Paris, 1954. viii + 239 pp. Illus. Paper, F. 1200.

The Theory of the Photographic Process. C. E. Kenneth Mees. Macmillan, New York, rev. ed., 1954. x + 1133 pp. Illus. $24.50.

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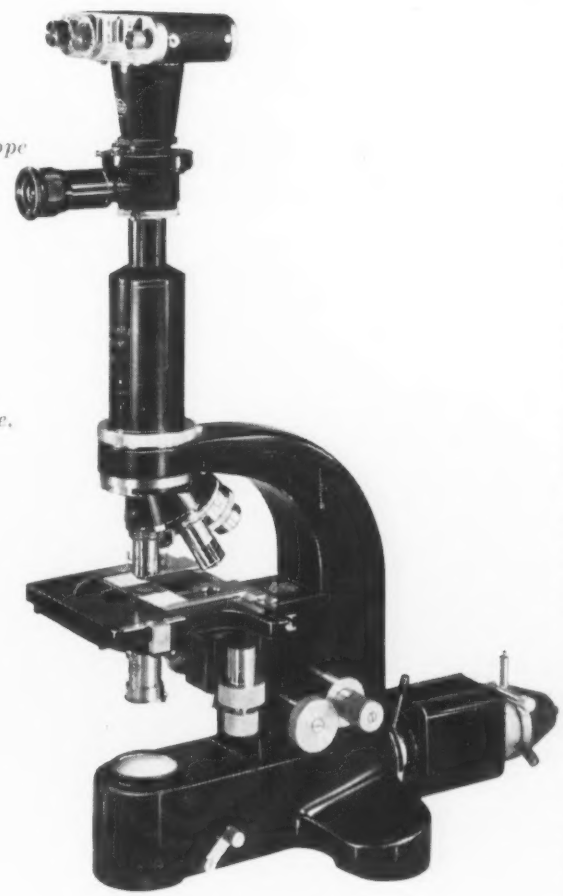

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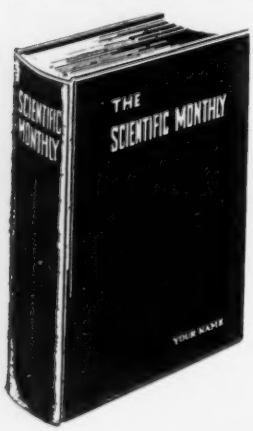

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Meetings

December

27–29. Soc. for Industrial and Applied Mathematics, 1st, Pittsburgh, Pa. (H. W. Kuhn, Dalton Hall, Bryn Mawr College, Bryn Mawr, Pa.)

28–30. American Economic Assoc., Detroit, Mich. (J. W. Bell, Dept. of Economics, Northwestern Univ., Evanston, Ill.)

28–30. American Meteorological Soc., Berkeley, Calif. (K. C. Spengler, 3 Joy St., Boston 8, Mass.)

28–30. American Physical Soc., Berkeley, Calif. (J. Kaplan, Dept. of Physics, Univ. of California, Los Angeles 24.)

28–30. American Soc. of Limnology and Oceanography, Berkeley, Calif. (B. H. K. Ketchum, Woods Hole Oceanographic Institution, Woods Hole, Mass.)

28–30. American Soc. of Zoologists, Chapel Hill, N.C. (R. T. Kempton, Vassar College, Poughkeepsie, N.Y.)

28–30. Archaeological Inst. of America, annual, Boston, Mass. (C. G. Yavis, Andover Hall, Francis Ave., Cambridge 38, Mass.)

28–30. Gerontological Soc., annual, Gainesville, Fla. (N. W. Shock, Baltimore City Hospitals, Baltimore 24, Md.)

29. Assoc. for Symbolic Logic, Pittsburgh, Pa. (J. Barlaz, Rutgers Univ., New Brunswick, N.J.)

29–30. History of Science Soc., New York, N.Y. (M. Boas, Brandeis University, Waltham, Mass.)

30. Mathematical Assoc. of America, Pittsburgh, Pa. (H. M. Gehman, Univ. of Buffalo, Buffalo 14, N.Y.)

30. Soc. of General Physiologists, Berkeley, Calif. (J. B. Buck, National Institutes of Health, Bethesda 14, Md.)

January

2–8. Indian Science Congress Assoc., 42nd, Baroda. (ISCA, 1 Park St., Calcutta 16.)

11–14. American College of Surgeons, Inter-American session, Lima, Peru. (M. L. Mason, 40 E. Erie St., Chicago 11, Ill.)

12. Astronomical Soc. of the Pacific, annual, San Francisco, Calif. (S. Einarsson, Leuschner Observatory, Univ. of California, Berkeley.)

12–15. World Symposium on Applied Solar Energy, Phoenix, Ariz. (M. L. Kastens, Stanford Research Inst., Stanford, Calif.)

13. American Genetic Assoc., annual business, Washington, D.C. (R. M. Cook, AGA, 1507 M St., NW, Washington.)

20–22. American Assoc. of Physics Teachers, New York, N.Y. (R. F. Paton, Dept. of Physics, Univ. of Illinois, Urbana.)

20–22. American Physical Soc., New York, N.Y. (K. K. Darrow, Columbia Univ., New York 27.)

21. Public Health Workshop on Dental Programs in Industry, 3rd, New York, N.Y. (A. J. Asgis, Hotel Statler, New York.)

24–27. American Soc. of Heating and Ventilating Engineers, Philadelphia, Pa. (A. V. Hutchinson, 62 Worth St., New York 13.)

26–2. Australian and New Zealand Assoc. for the Advancement of Science, Melbourne, Australia. (J. R. A. McMillan, 157 Gloucester St., Sydney.)

27. American Federation for Clinical Research, western section, Carmel, Calif. (A. B. French, College of Medicine, Univ. of Utah, Salt Lake City.)

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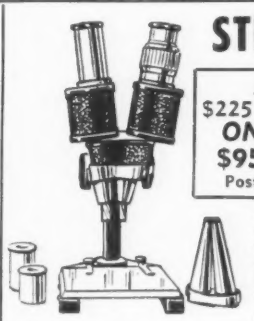

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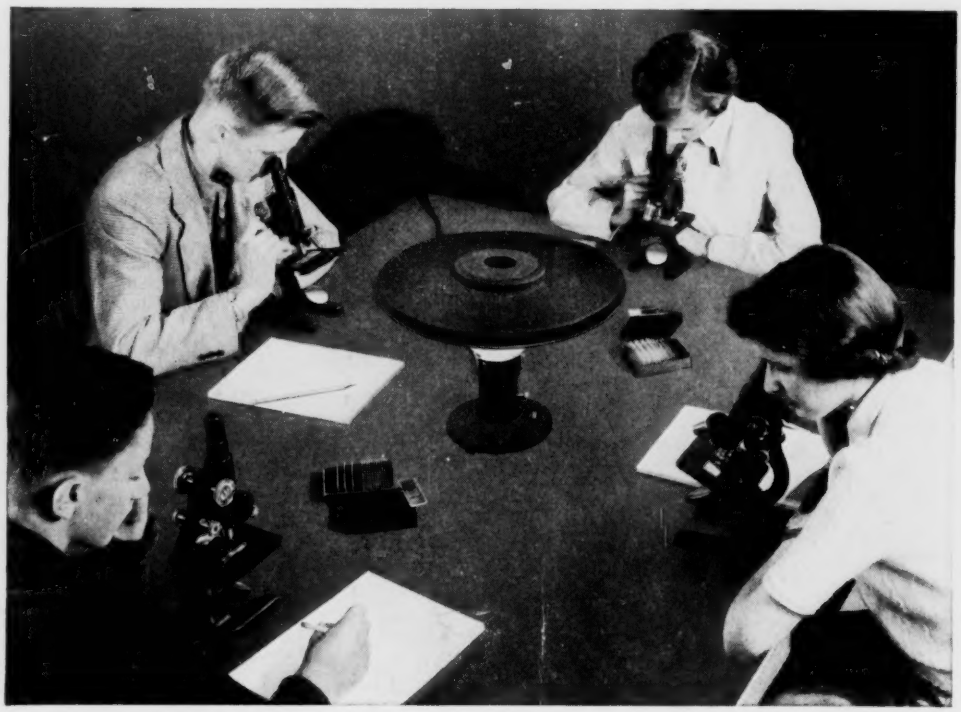

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